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THE BRITISH JOURNAL OF METALS

Vol. 51 No. 308 JUNE, 1955 Monthly: TWO SHILLINGS

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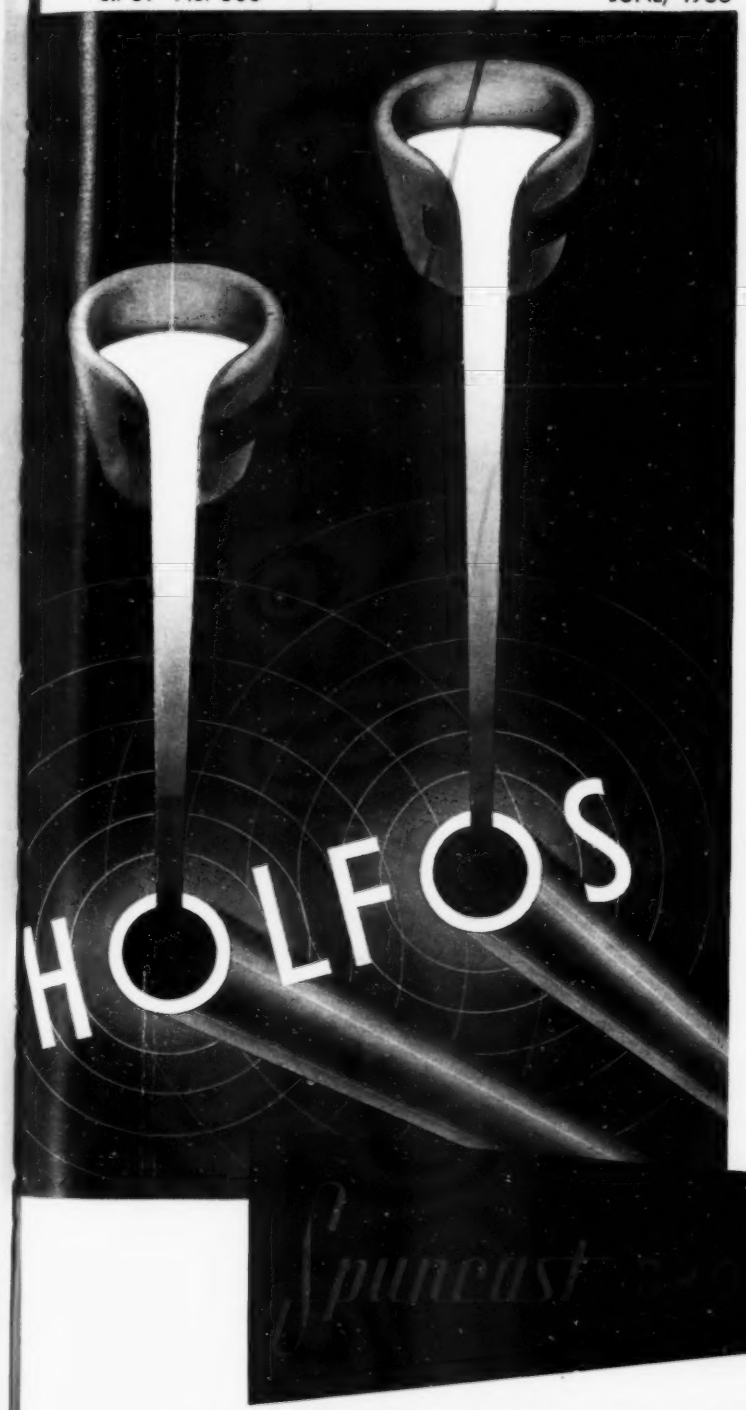

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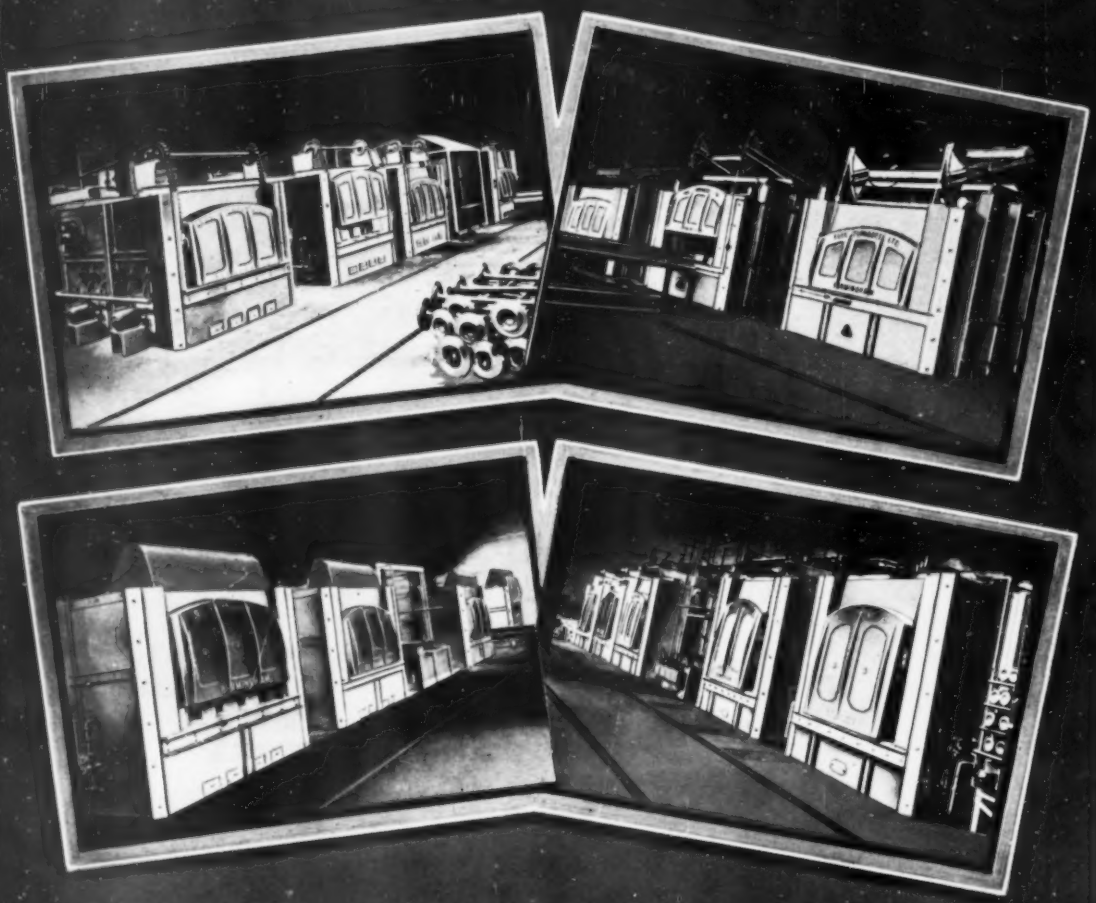

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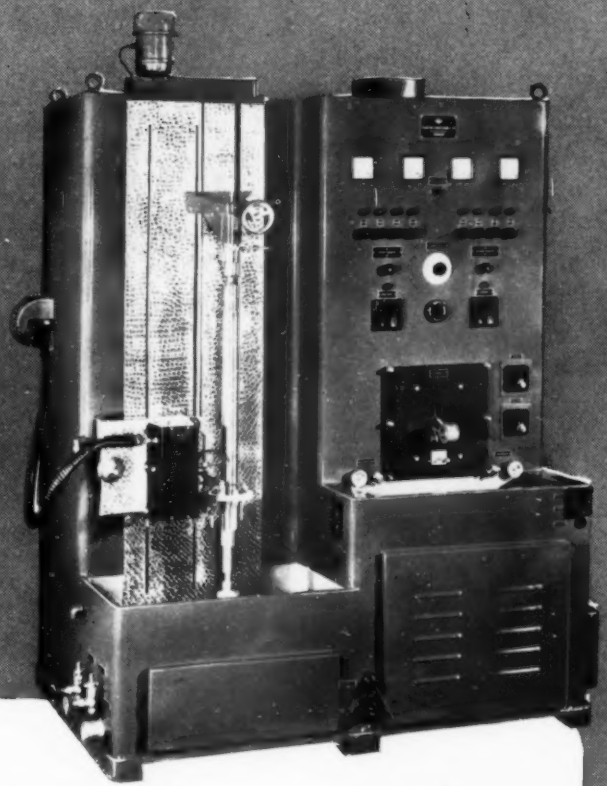

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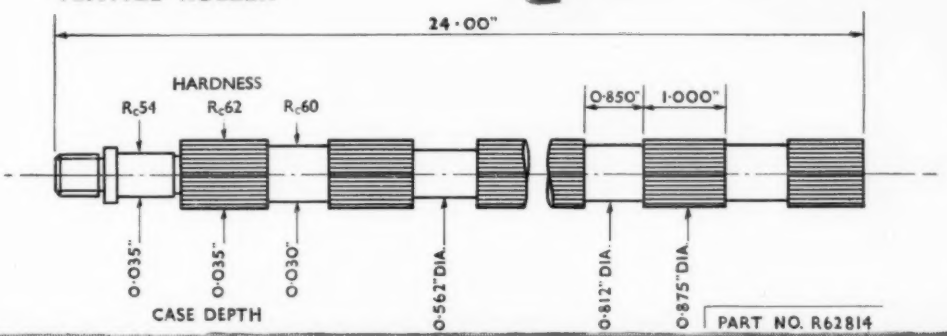

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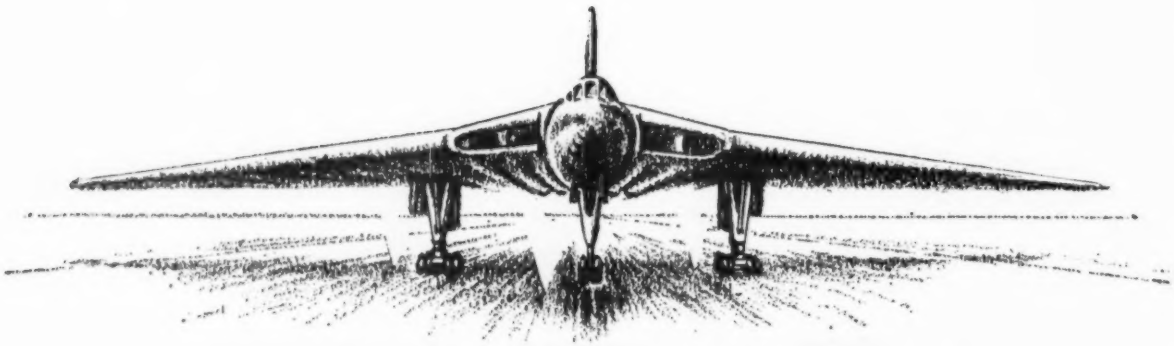

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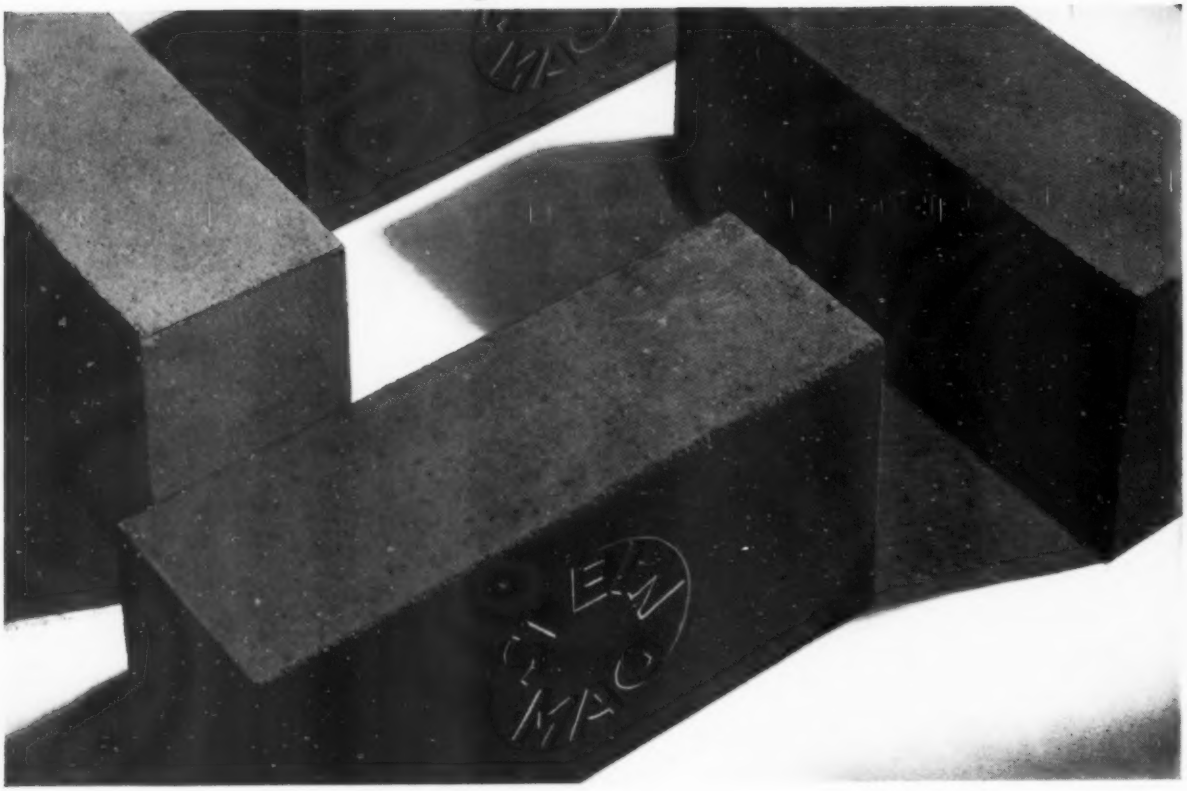

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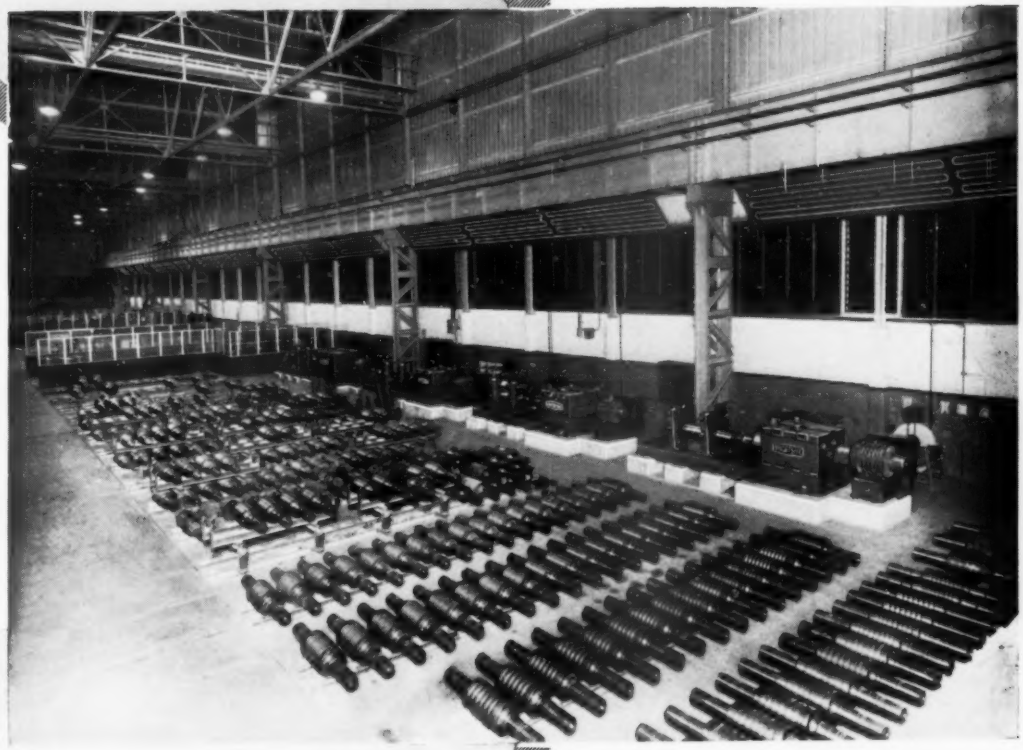

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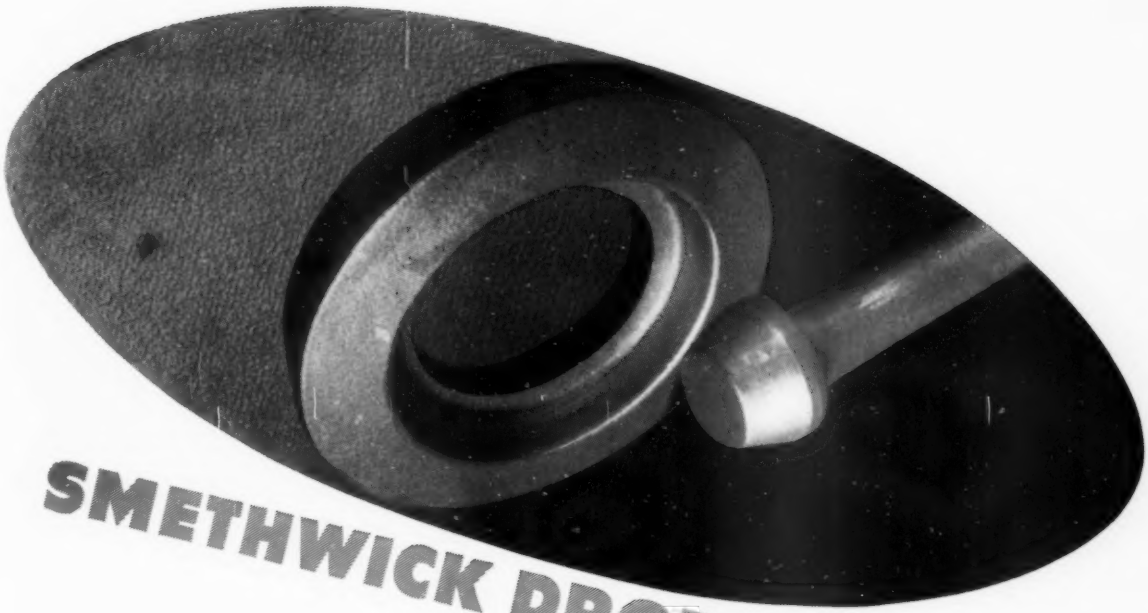

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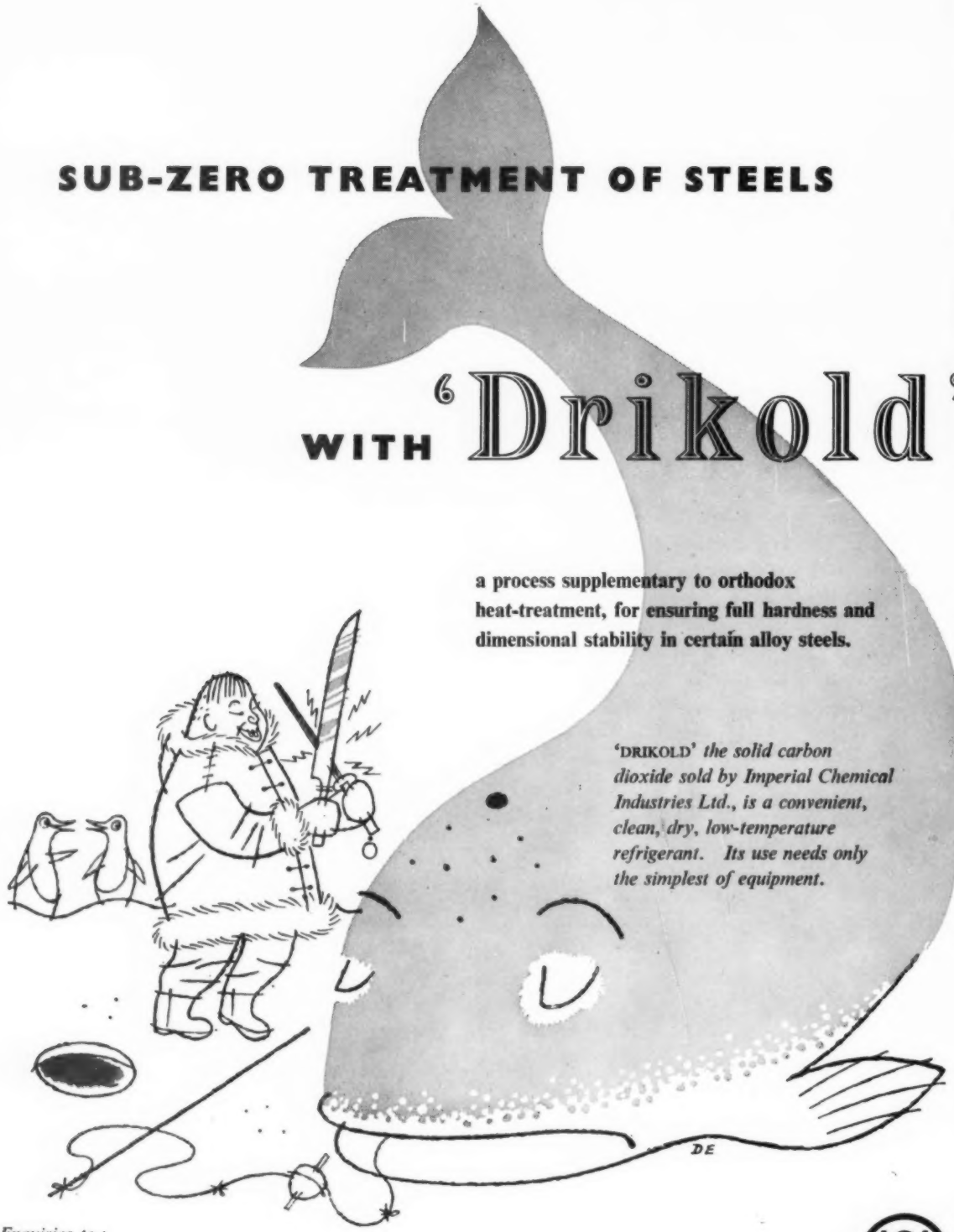

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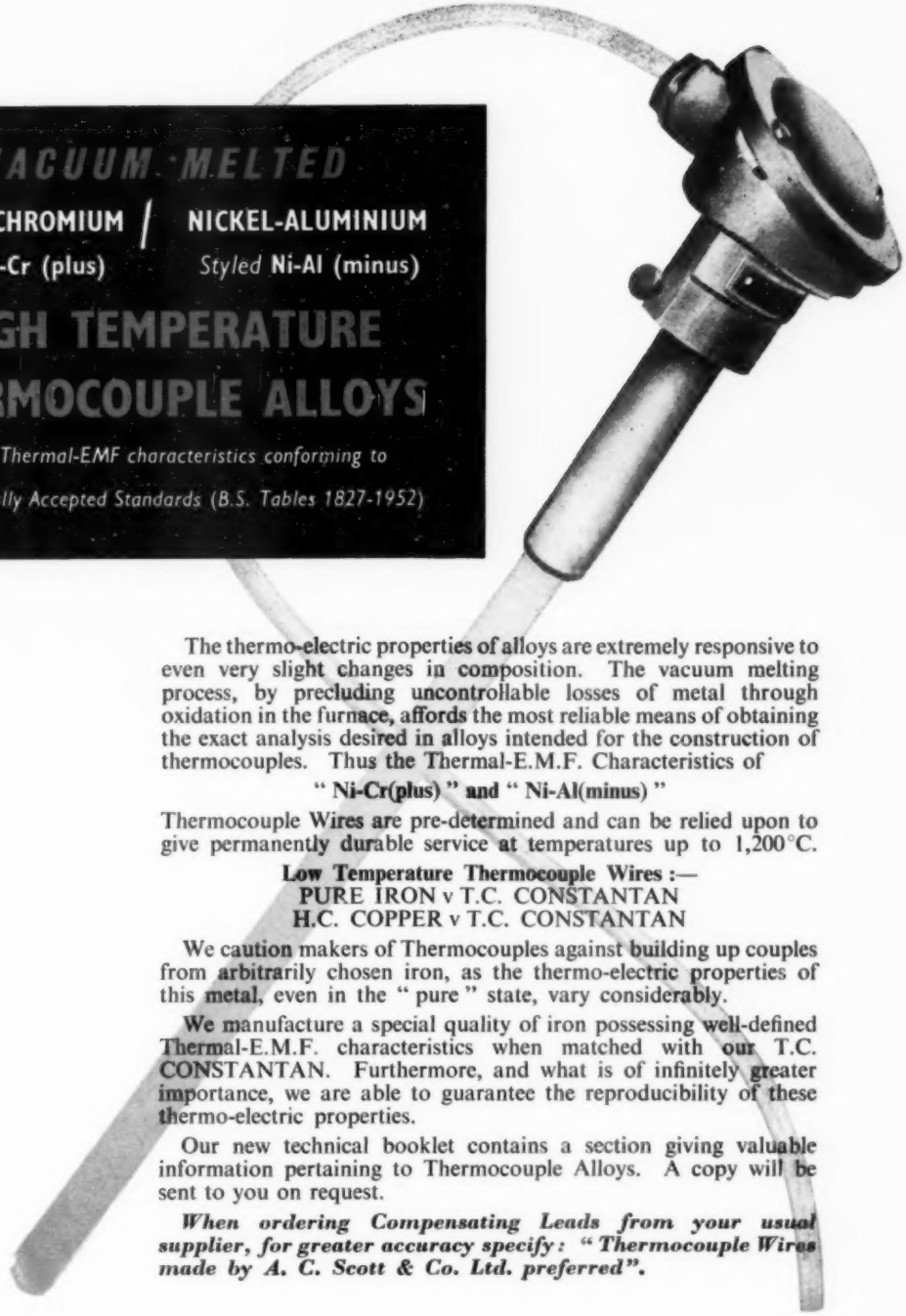

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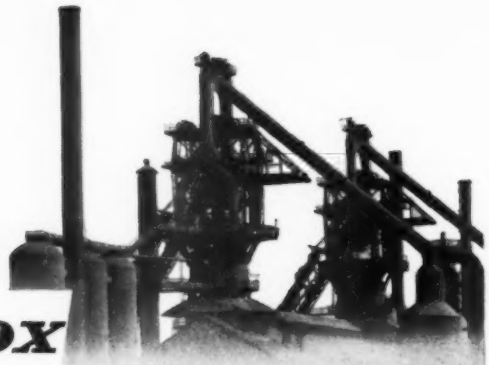

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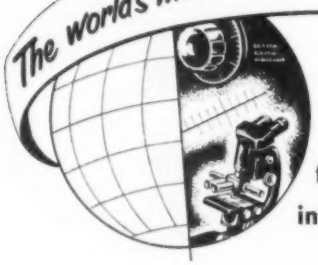

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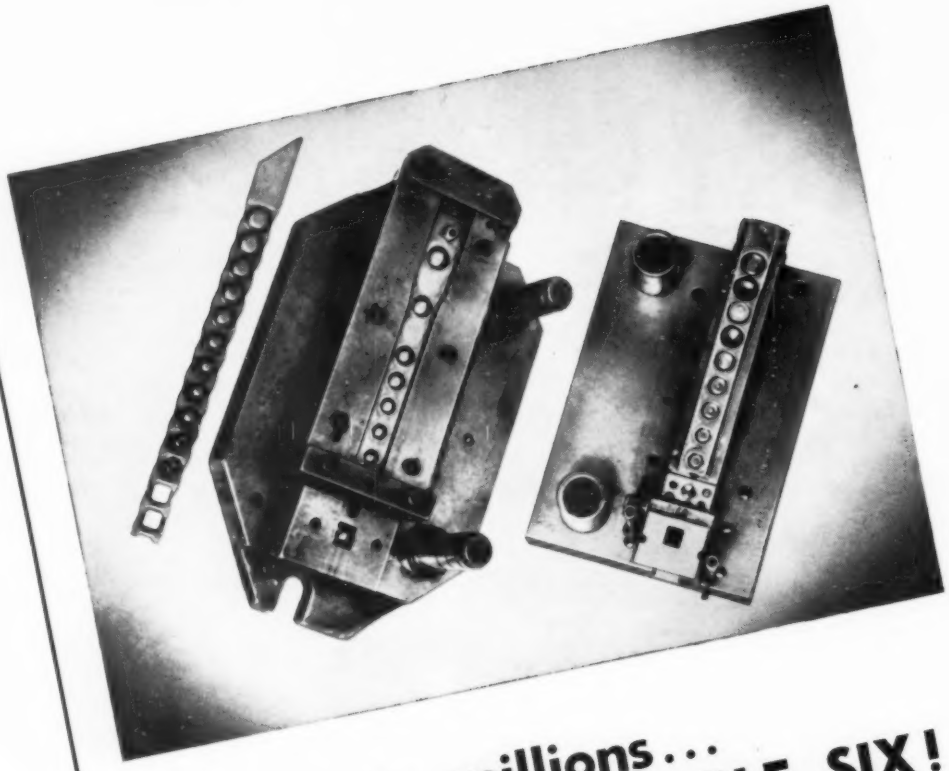

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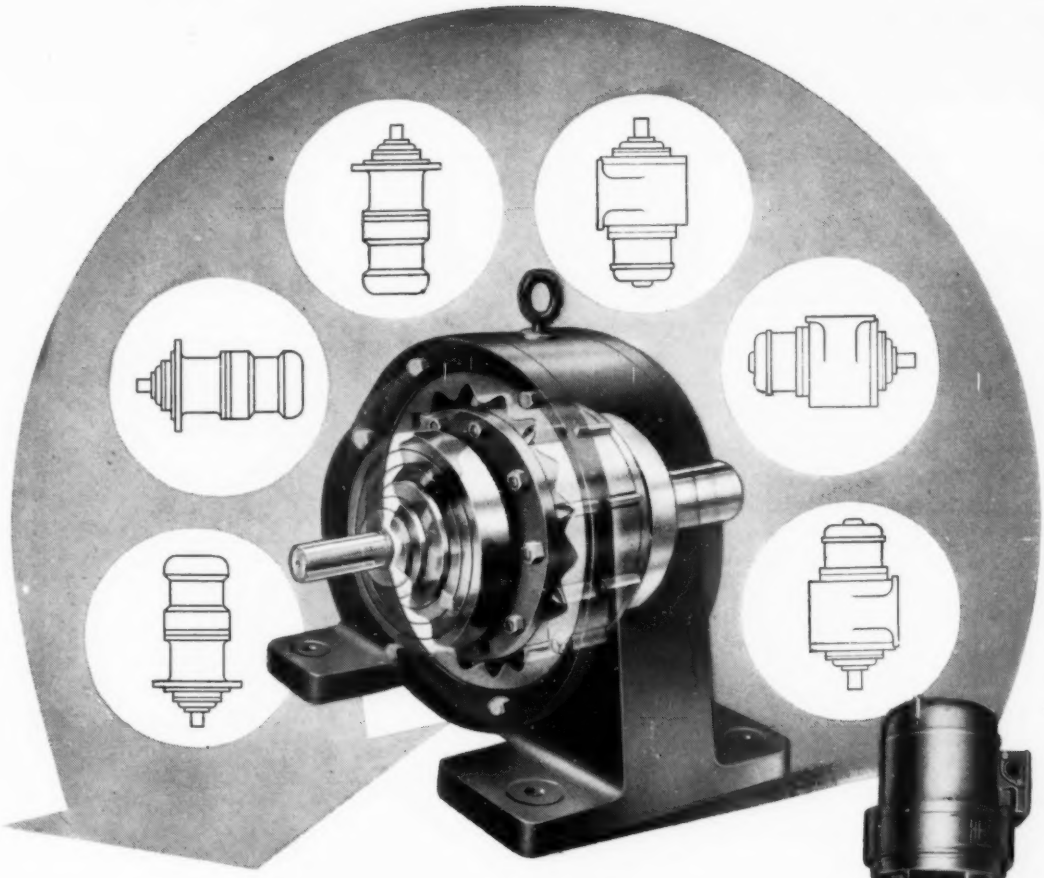

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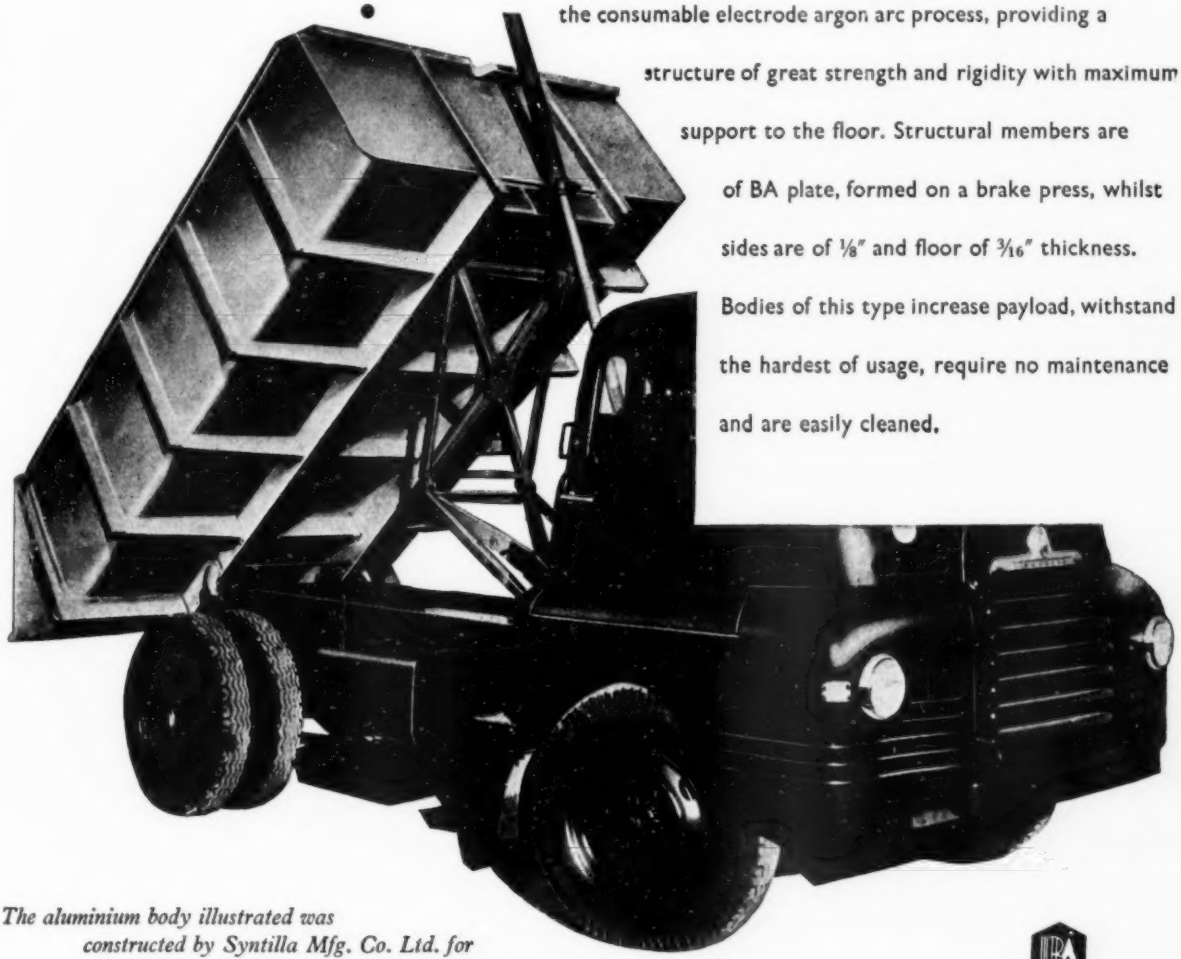

The aluminium body illustrated was constructed by Syntilla Mfg. Co. Ltd. for Lorry Bodies (Luton & Dunstable) Ltd.

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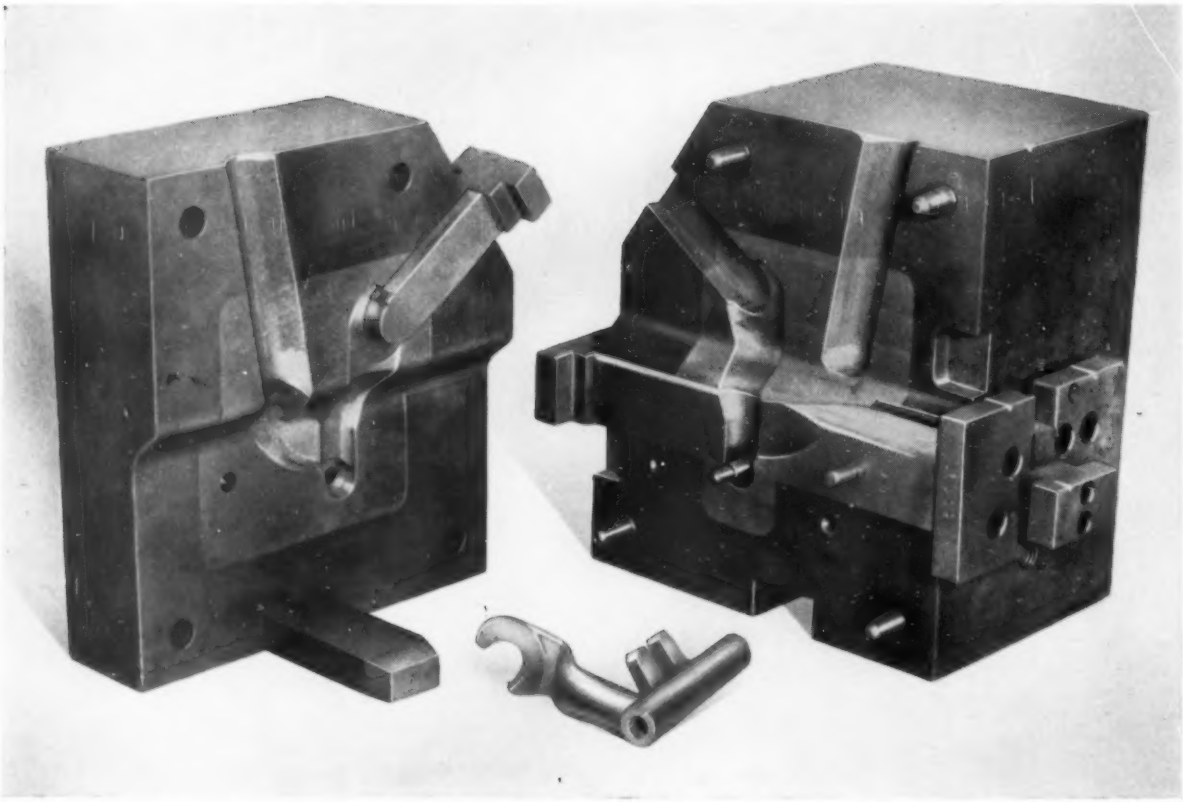

Dies with inserts of Nimonic 80 have become standard for aluminium-bronze gravity die-casting. *(By courtesy of Sagar Richards Ltd.)*

Moulds for gravity die-casting are continually exposed to intense heat and to thermal shock. When casting aluminium-bronze, for instance, the pouring temperature is in the region of 1,150 C. For the dies to retain their accuracy, the die material must resist damage from scaling and oxidation and, to be economically justified, it must give long service. Messrs. Sagar Richards Ltd. of Luddendenfoot, near Halifax, who produce a wide range of aluminium-bronze die-castings, mainly for the automobile industry, have, for several years, used Nimonic alloys for die inserts and cores. Nimonic 75 and Nimonic 80 have extended die life so considerably that their use is now practically standard.

This example is typical of the many high-temperature problems which have been solved by the use of Nimonic heat-resisting alloys. Our Technical Service is always pleased to advise on the choice of suitable materials for use in severe conditions.

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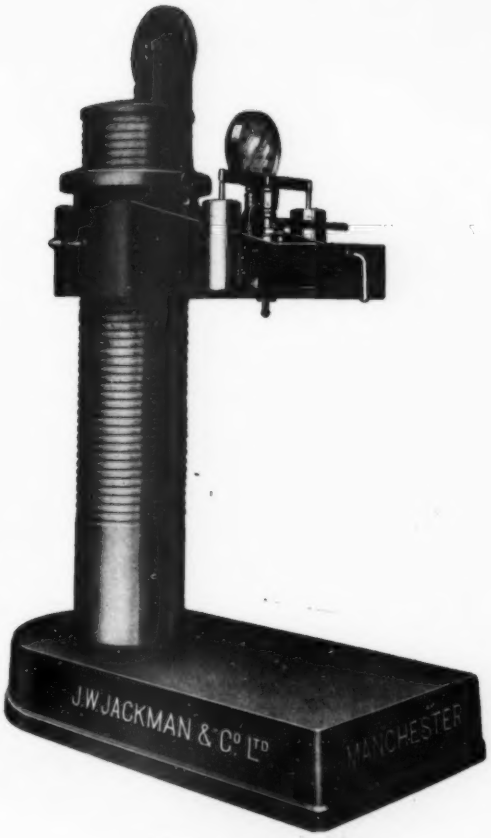
HT95

Testing Machines



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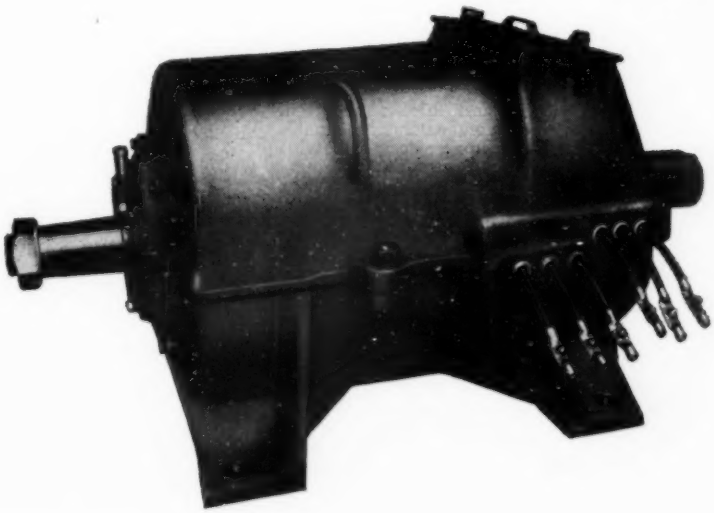

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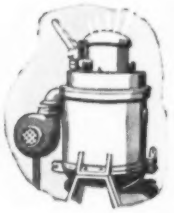

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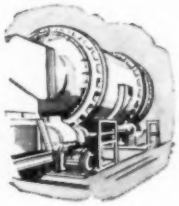

These are just a few of the extensive range of G.R. Refractory Compositions. Full particulars, technical advice and assistance in the selection and application of the most suitable composition are available on request.

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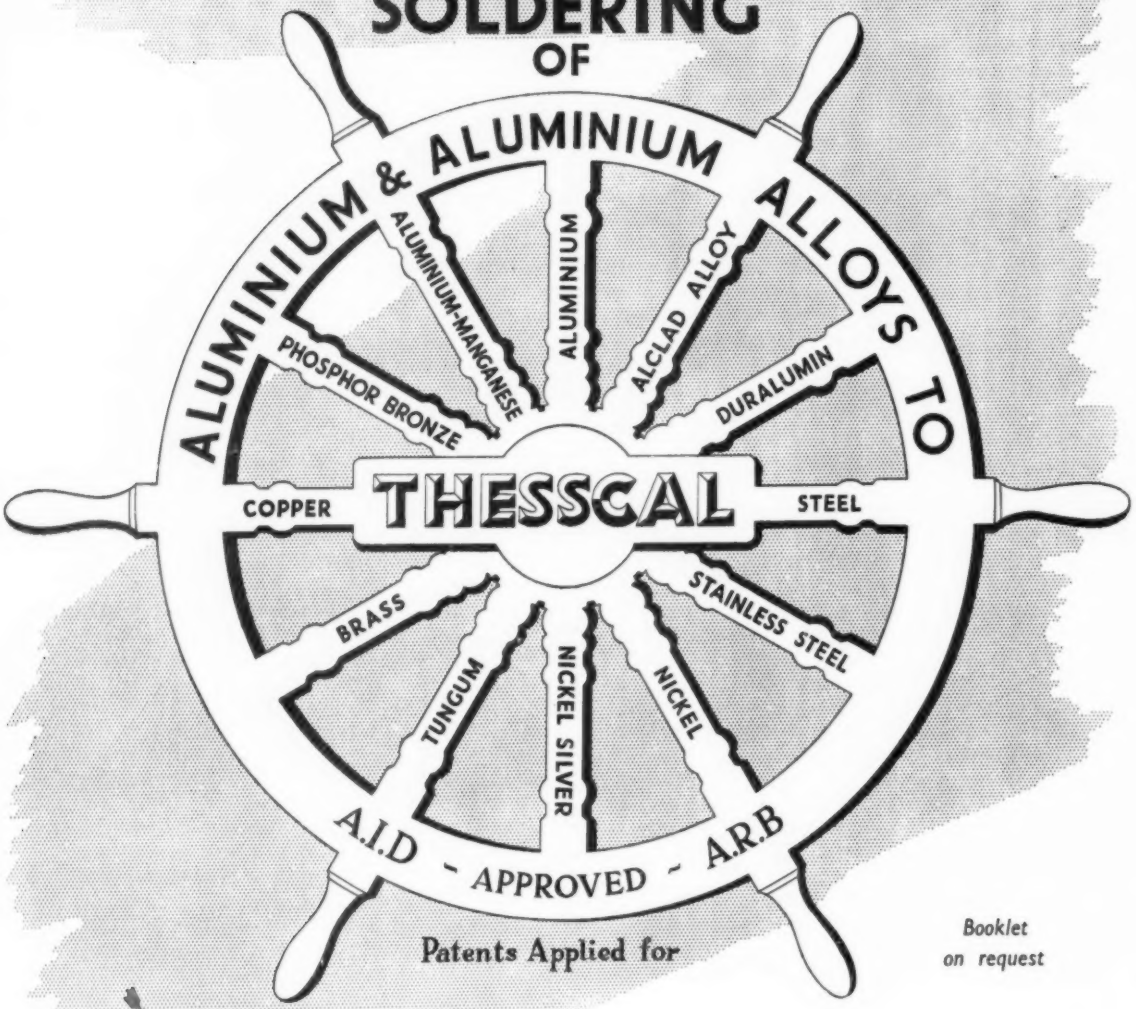

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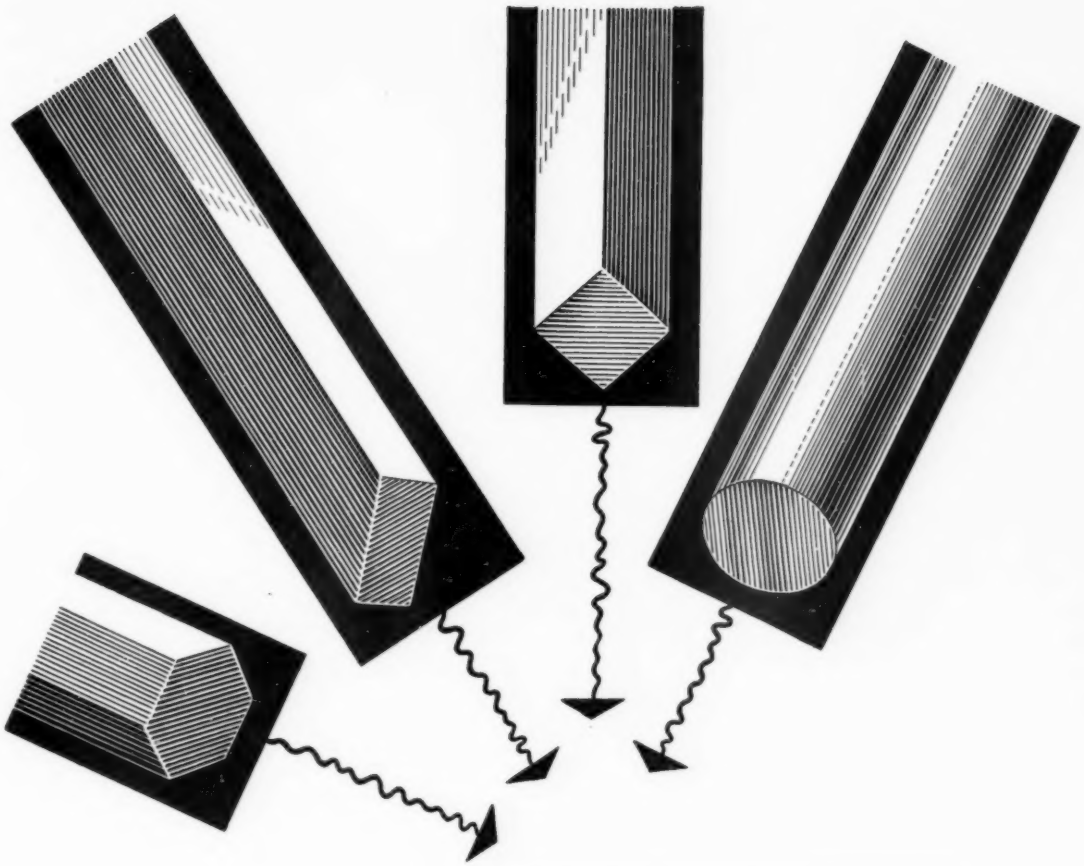

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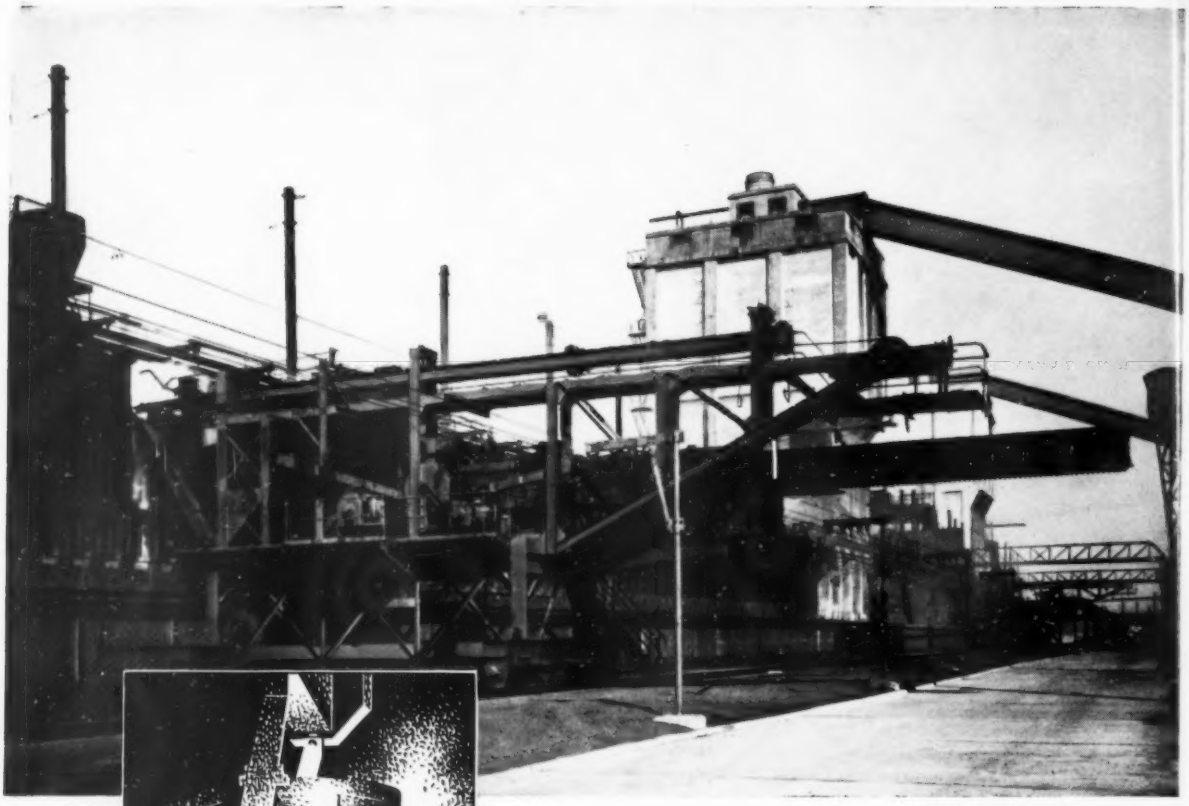

Coke Ovens in British Steelworks

The pusher side of five batteries of W-D Becker Coke Ovens built at the Clyde Ironworks, Glasgow, for Colvilles Ltd., in 1939, 1940 and 1952. Altogether there are 135 ovens with a total carbonising capacity of 3,242 tons of coal per day.

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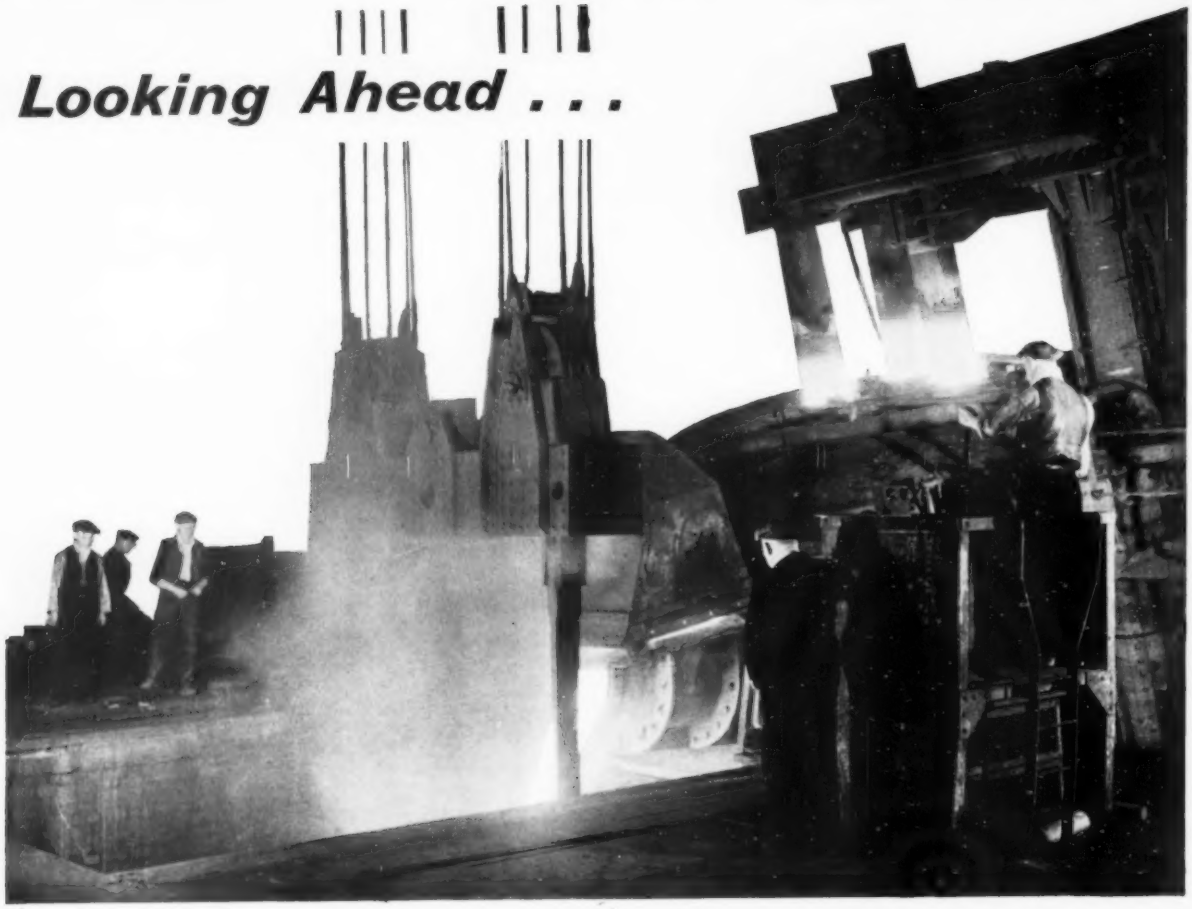

Photograph by courtesy of English Steel Corporation, Ltd.

. . . with 16″ Electrodes

This 30-ton Electric Arc Furnace, powered by a 6,000 kVA Transformer is one of a large installation at the Works of English Steel Corporation, Ltd., and represents a fine example of modern steel-making practice.

Electric Arc Furnaces offer many advantages for the economical production of carbon and alloy steels, and the 16-in. diameter electrodes used in this furnace are supplied by British Acheson.

Keeping abreast of the trend towards larger furnaces, British Acheson now manufacture graphite electrodes up to 20 in. diameter.

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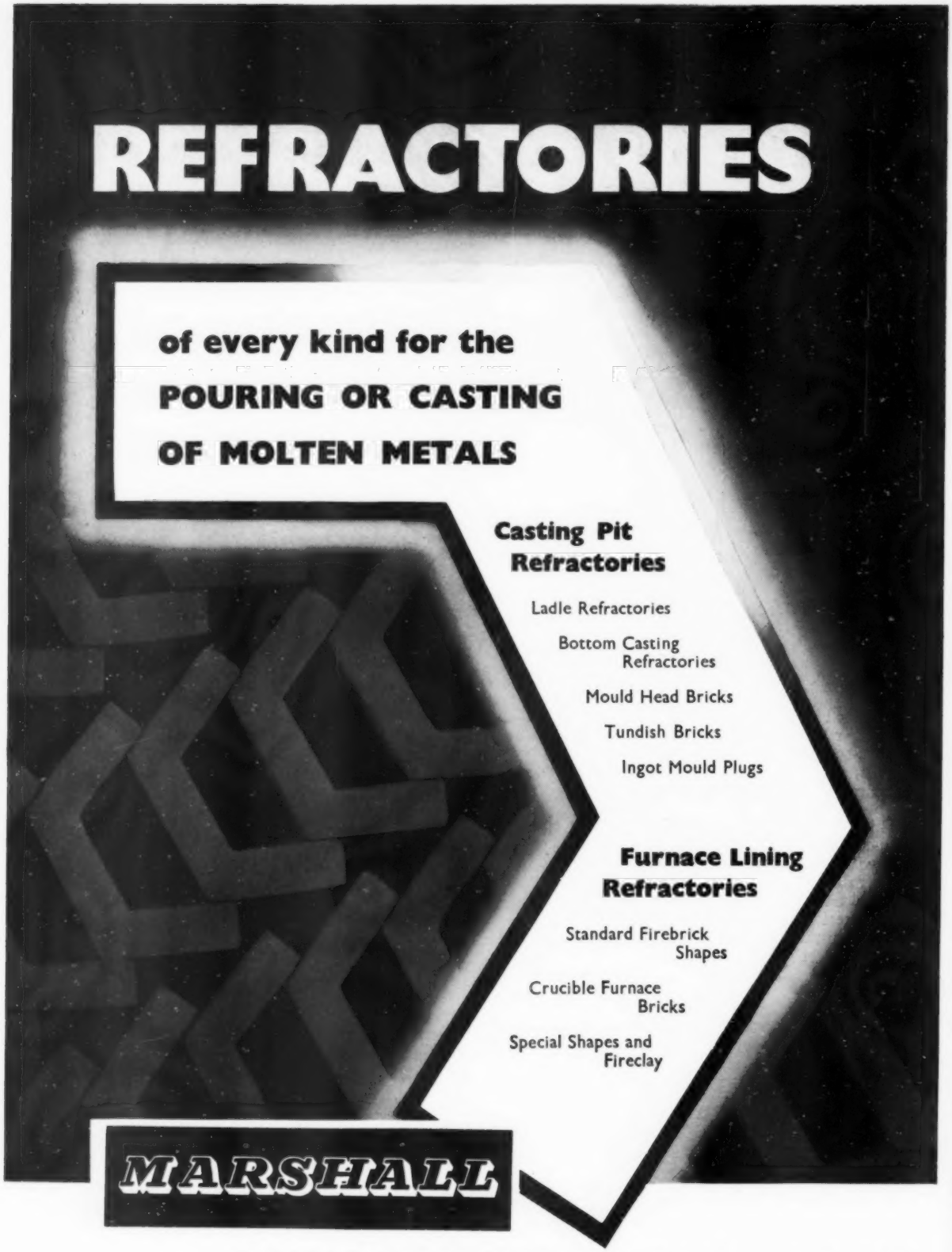

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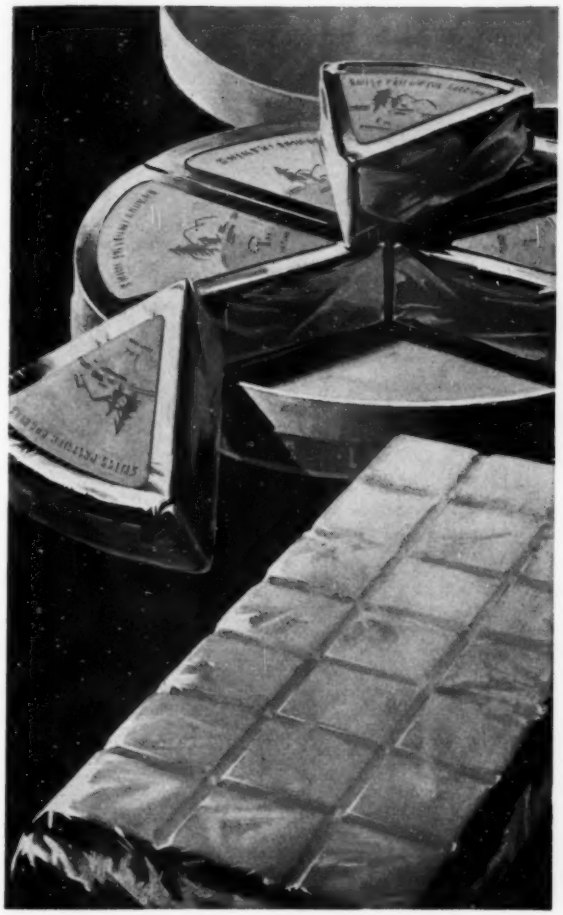
ALUMINIUM AT WORK



From the familiar . . . . . to the less familiar

Shining packs and containers of aluminium foil have won outstanding success in post-war markets. Used for a wide range of food products, this economical and adaptable packaging material keeps good things at their best. Its clean and shining surface—plain or coloured—makes an ideal starting point for attractive pack design, not only for foil wraps but for adaptable lightweight containers like this new type of throwaway cup. These handy containers can be hermetically sealed for the packing of cheese, ice cream, meat pastes and many processed foods. Have you a product that would pack better, keep longer and sell faster in aluminium?

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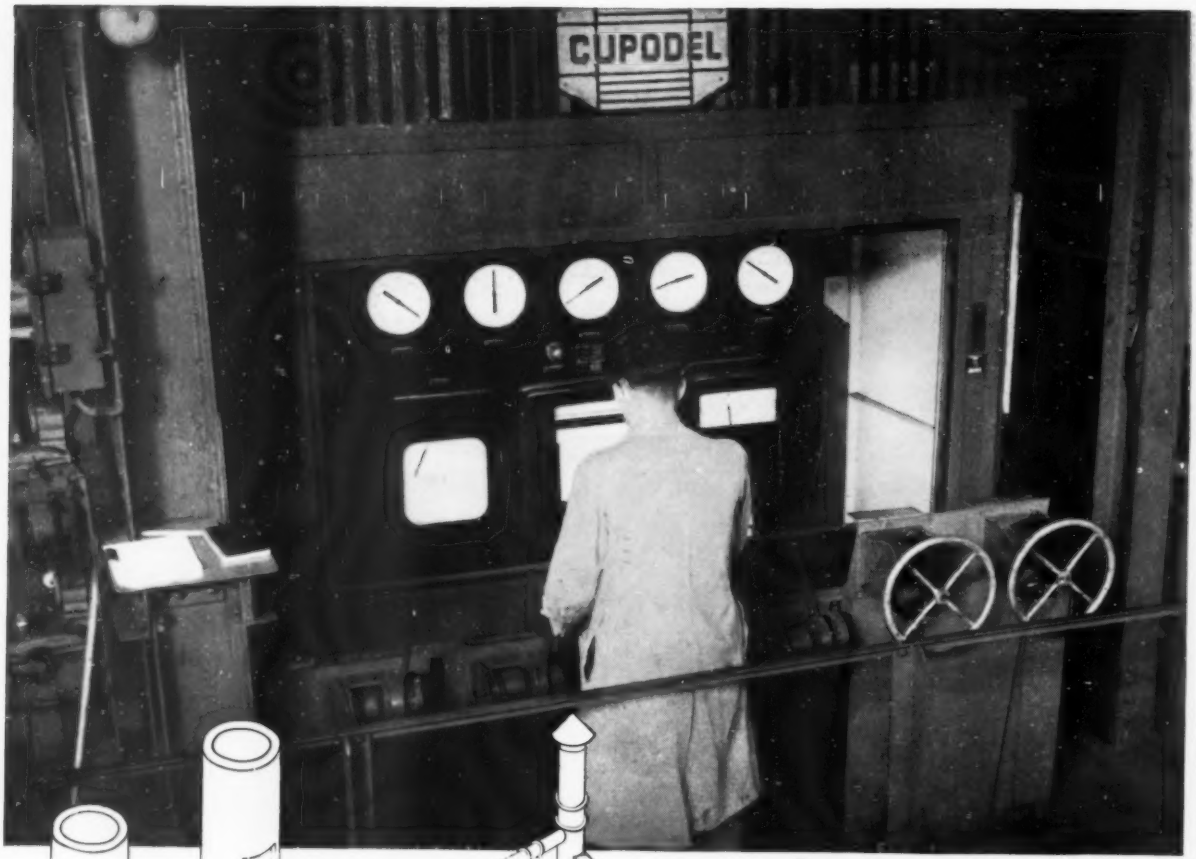
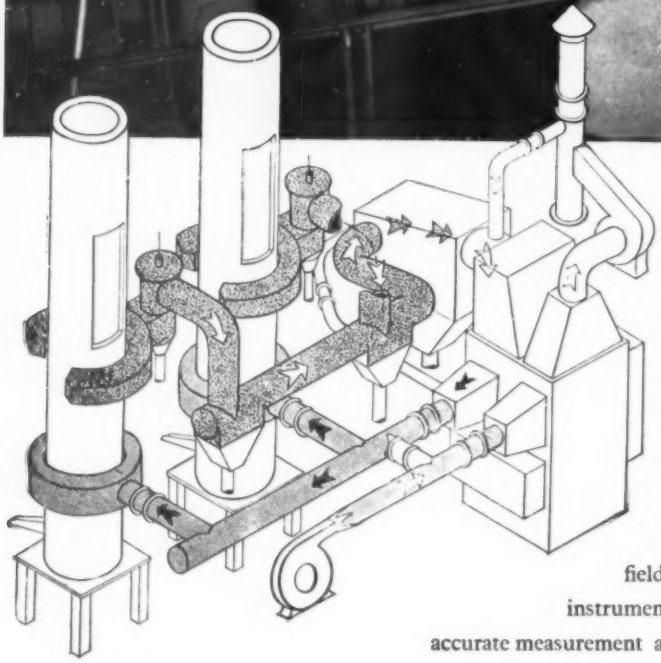
ELLIOTT

Hot Blast Control for Cupolas



Photograph by courtesy of Dartmouth Auto Castings Ltd. and diagram by courtesy of Cupodel Ltd.



Hot Blast Control is a major factor in ensuring the economical production of pig iron in blast furnaces. In modern iron foundry practice, too, it is of equal importance in the reduction of iron in cupolas.

Cupodel Ltd., of London and Birmingham, have applied this principle, introducing regenerative heating into cupolas with resultant increases in productivity and savings in cost. The Elliott organisation, whose specialist engineers have many years experience of measurement and control in this field, have successfully co-operated with Cupodel in the instrumentation of a number of these installations, providing accurate measurement and control of temperature, flow, pressure and draught.

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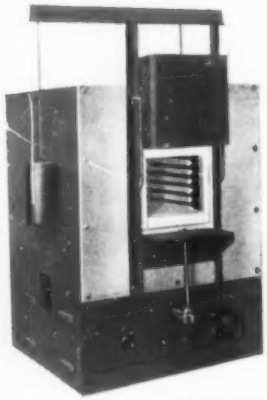
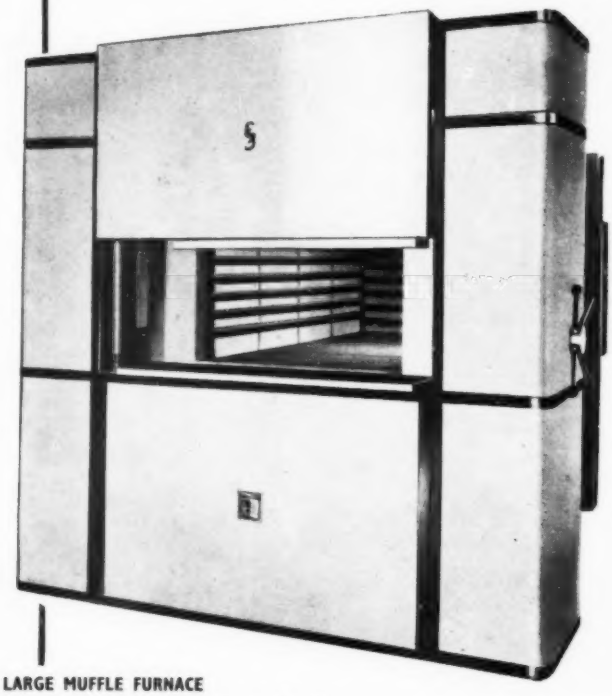
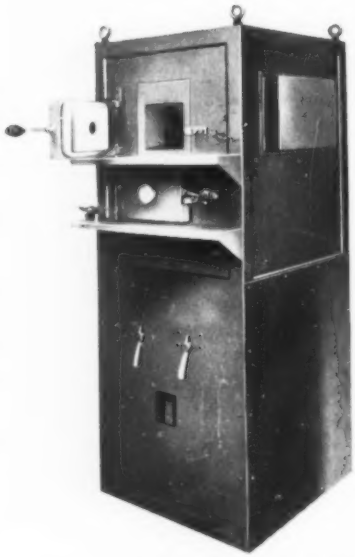
Electric Furnaces



BENCH MOUNTING FURNACE
Muffle 10in. x 7in. x 6in.



LARGE MUFFLE FURNACE
Muffle 5ft. 6in. x 3ft. 0in. x 1ft. 9in.



DOUBLE MUFFLE FURNACE
Each Muffle 1ft. 2in. x 7in. x 6in.

Here are illustrated a few of our range of Muffle Furnaces. We supply a large variety of furnaces for numerous purposes and will quote for a furnace to suit any specific requirements.

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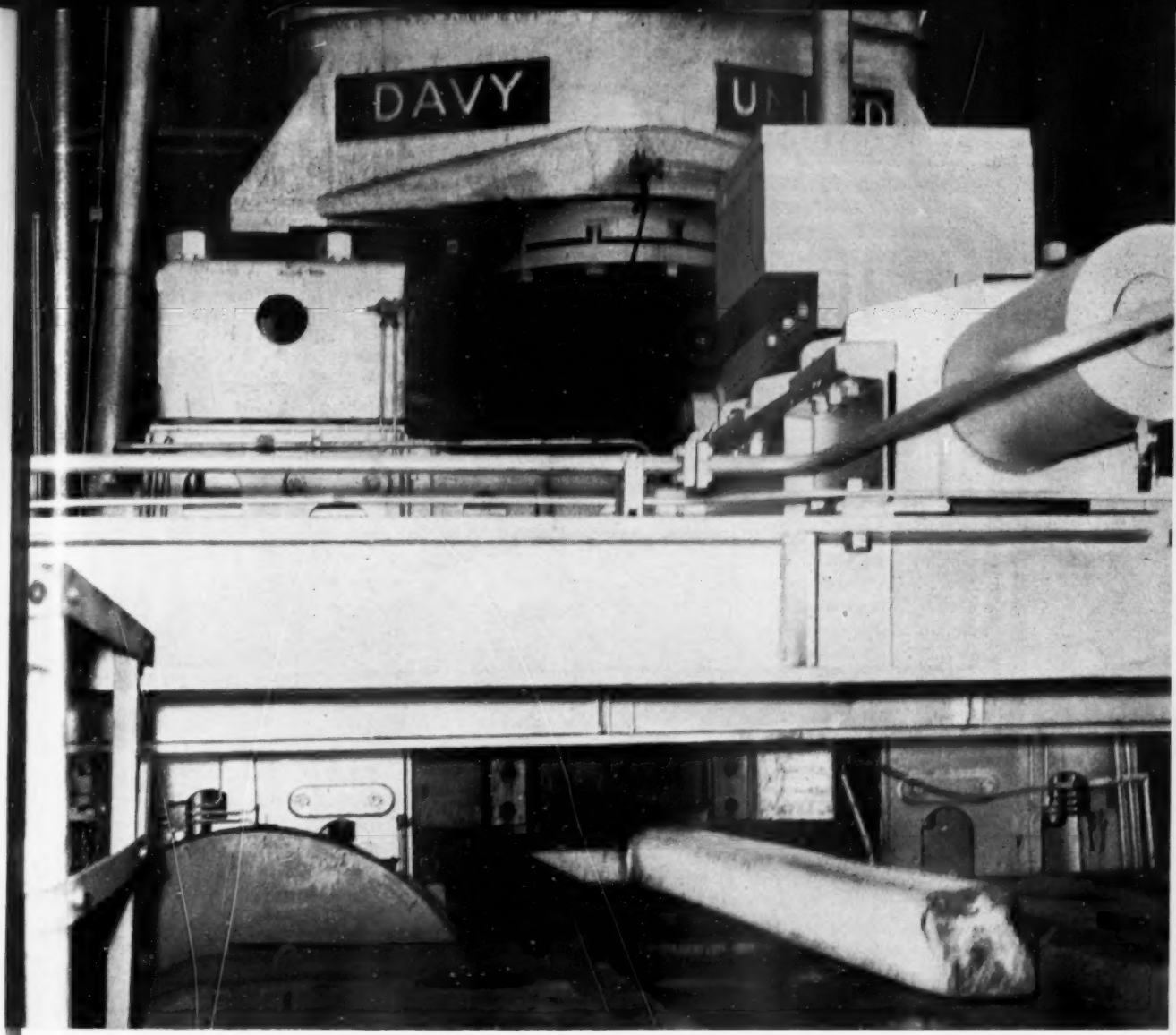
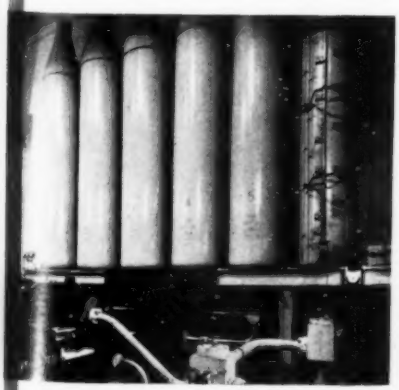


The shear making a cut on a 10" x 12" bloom.

NEW HOT BLOOM SHEAR at Cargo Fleet



Pump and Air Hydraulic Accumulator System serving the shear, installed in the Pump House.

This new Down-and-Upcutting Hot Bloom Shear has just been installed in the Cargo Fleet Works of South Durham Steel & Iron Company Limited. Complete with pump and accumulator drive, the shear has a blade load of 1,800 tons and is capable of shearing blooms 20" x 30", or 600 square inches cross-sectional area. It replaces one of upcutting steam hydraulic type, also bearing the Davy mark, which has given 50 years' continuous service to Cargo Fleet.

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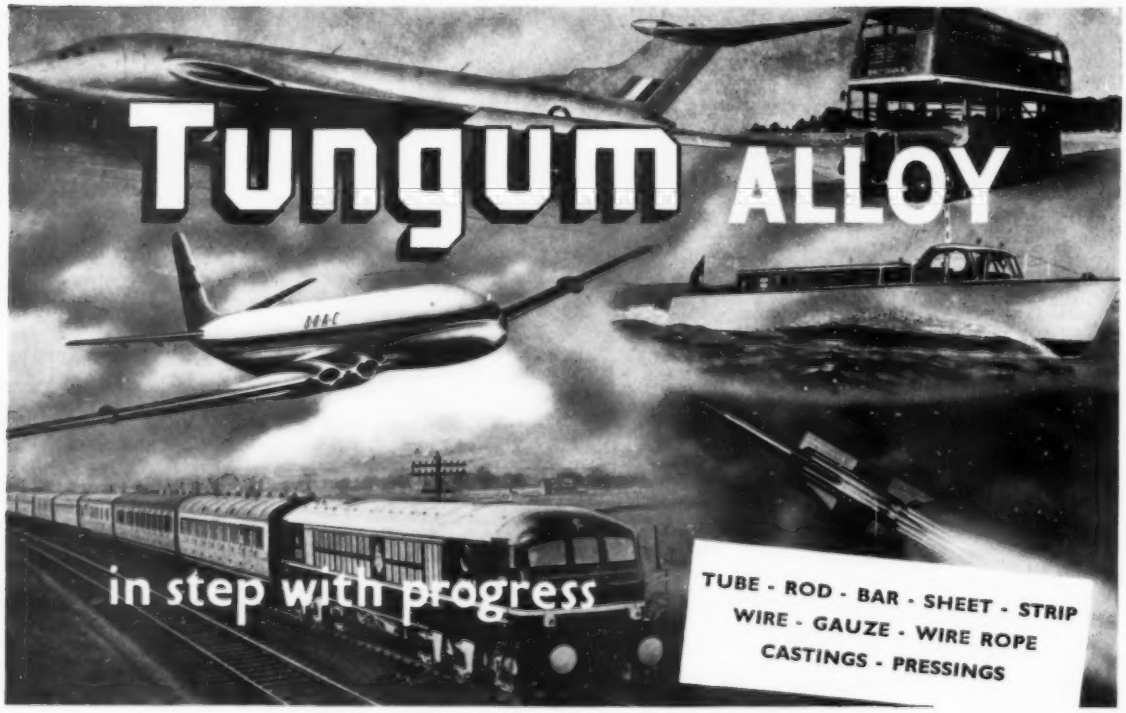

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only one of the aids to higher Productivity that Electricity can bring you.

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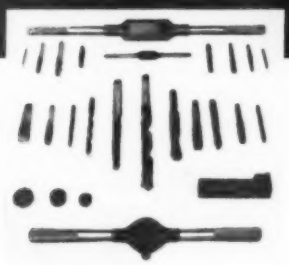

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This perfectly functioning furnace, always under automatic temperature control, produces absolutely uniform parts, batch after batch. And the oxide film which is deposited not only gives this greatly increased wear, but gives you scale-free finish, with both ferrous and non-ferrous parts eliminating after-cleaning operations.

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THE BRITISH JOURNAL OF METALS
INCORPORATING THE METALLURGICAL ENGINEER

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CONTRIBUTIONS

Readers are invited to submit articles for publication in the editorial pages: photographs and/or drawings suitable for reproduction are especially welcome. Contributions are paid for at the usual rates. We accept no responsibility in connection with submitted manuscript. All editorial communications should be addressed to The Editor, "Metallurgia," 31, King Street West, Manchester, 3.

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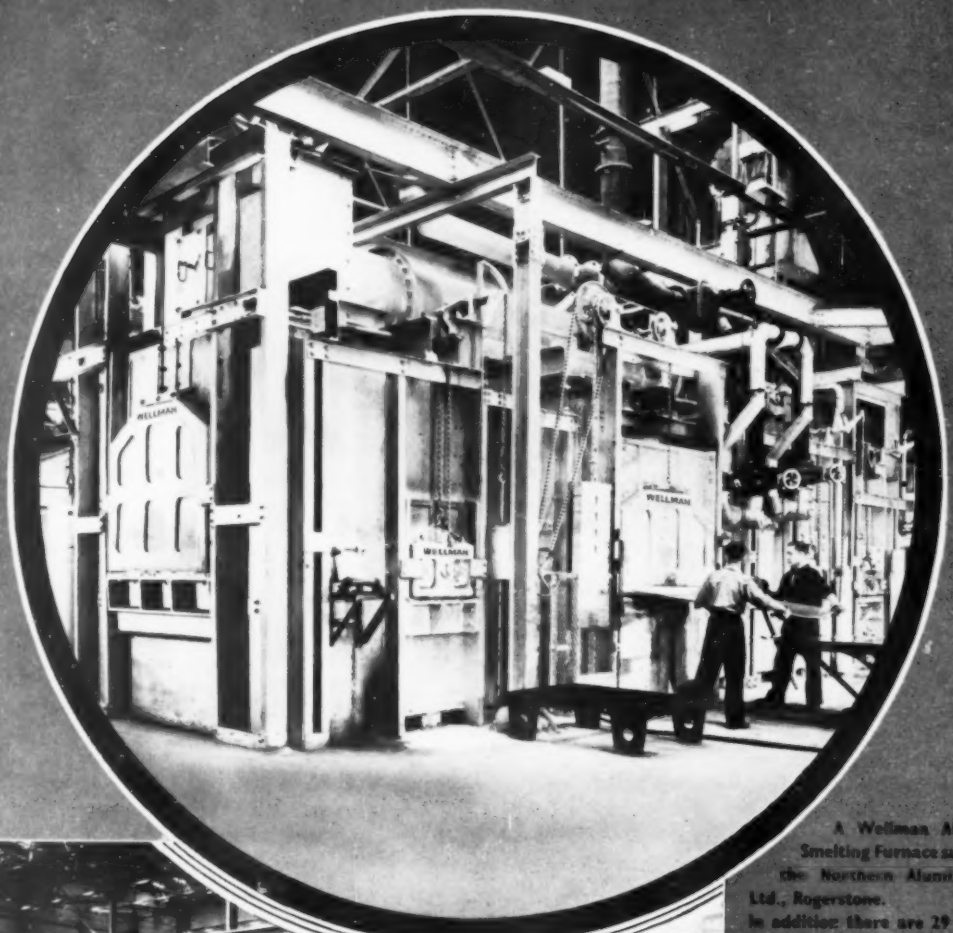
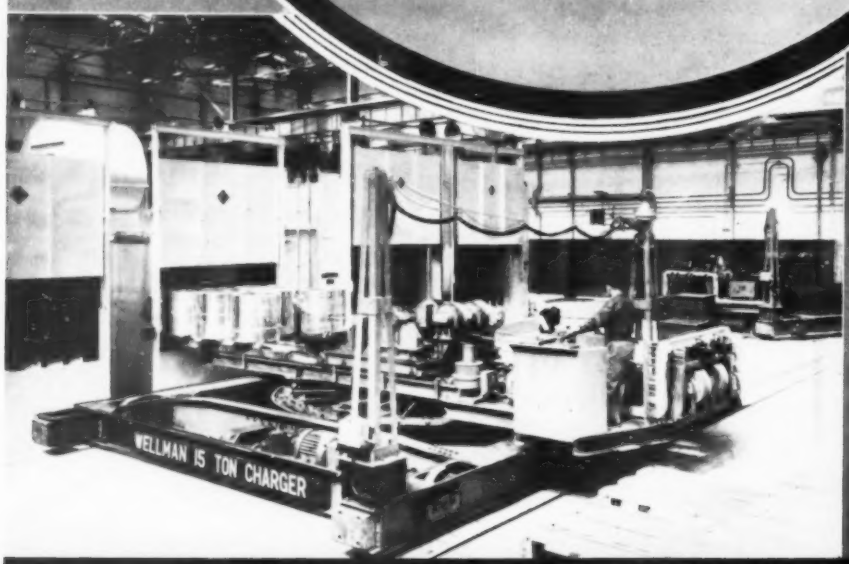
WELLMAN

Furnaces and Mechanical Handling Equipment



A Wellman Aluminium Smelting Furnace supplied to the Northern Aluminium Co. Ltd., Rogerstone.
In addition there are 29 Wellman Cranes, ranging in capacity from 3 tons to 40 tons, in operation at these Works.



Wellman 15 ton Finger Type Chargers and Turntable in service at the British Aluminium Co. Ltd., Falkirk. This installation also includes a 10,000 lbs. Wellman Slab Discharger and a 10,000 lbs. Block Handling Crane.

THE WELLMAN SMITH OWEN ENGINEERING CORPN. LTD.
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, SOUTH STAFFS.

METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

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Transatlantic Link

THE beginning of June is marked by two events of considerable interest in the metallurgical world. In the first place the American Institute of Mining and Metallurgical Engineers and the American Society for Metals have accepted invitations from the Iron and Steel Institute and the Institute of Metals, and from the leading metallurgical societies in Belgium, France, Germany and Sweden, to send representatives to a Joint Metallurgical Societies Meeting to be held in Europe from June 1st to 18th.

The Meeting is notable in that it is the first time that representatives of American and European societies have met together for formal technical discussions. It is being held in four parts—the first in Great Britain, (from June 1st to 7th), the second in Dusseldorf, the third in Liege, and the final section in France. At the end of the main meeting, there will be tours to other European countries, including Austria, Spain, Sweden and Switzerland.

The objects of the meeting are : to establish personal contacts between experts in the U.S.A. and Canada and in Europe ; to provide opportunities for scientific and technical discussion ; to enable visitors from the U.S.A. and Canada to see something of the metallurgical industries of Europe ; and to foster better understanding and co-operation among all concerned. The subjects for discussion cover a wide range of processes in the iron and steel and non-ferrous industries, metallurgical education and training in industry, and research.

The American Institute of Mining and Metallurgical Engineers was first organised in 1871, some two years after the founding of our own Iron and Steel Institute, and its membership has risen from 71 in its first year to over 16,000. Although the Institute had, from its inception, been concerned with both mining and metallurgical activities, the words "and Metallurgical" were not introduced into its title until 1919. To-day it has 10 Divisions, four forming the Mining Branch, three the Petroleum Branch, and three—Institute of Metals, Iron and Steel, and Extractive Metallurgy—the Metals Branch.

The American Society for Metals is much younger—it was established in 1913 in Detroit—but it is the largest group of metal engineers in the world. Its original membership of 12 has now grown to over 22,000, 60% of which is employed in the field of metal fabrication, 25% in plants producing ferrous and non-ferrous metals, and 15% in education and research. The Society is active in the organisation of national meetings, and was the sponsor of the first World Metallurgical Congress.

Since the end of the war, several Productivity Teams and Technical Assistance Missions have visited the United States to study various aspects of metallurgical development, and these tours have been supplemented by private visits of representatives of individual firms. As a result, there has been a greater appreciation in this country of the possibility of increasing productivity by such things as improved materials handling and greater co-operation between management and workers. There have, too, been technical developments whose introduction has followed these visits. It would be erroneous, however, to assume that there is only a possibility of one way traffic in this field, and no doubt in the course of discussion between experts from both sides of the Atlantic mutual benefit was derived. In the same way, although one of the objects of the present Meeting is to enable visitors from the U.S.A. and Canada to see something of the metallurgical industries of Europe, it is on matters of mutual benefit that the emphasis has been rightly laid in the organisation of the Joint Meeting, and it is the hope of those responsible for the arrangements on this side, that our visitors will return to the United States feeling that their visit has been well worth while.

One metallurgical process which has its roots in both Europe and the United States is the almost universally used electrolytic method of extracting aluminium from alumina, for the method was discovered independently by Hall in America and Héroult in France. It is appropriate, therefore, that the Aluminium Progress Exhibition, organised by the Aluminium Development Association to celebrate a century of British progress with aluminium, which is to be held at the Royal Festival Hall from June 1st to 10th, should coincide with the visit of our transatlantic colleagues.

Progress was not particularly rapid until the turn of the century, although even at that time the world output was between 5,000 and 10,000 tons per annum. Since then, however, production has been doubled roughly every 10 years, until in 1954 a record figure of about 3 million tons was reached. The last 10 years have been particularly important in the development of the British aluminium industry as, towards the end of the war, the prospects of being able to utilise to the full the then swollen capacity for producing and fabricating aluminium were not at all certain. It is a measure of the efforts made by the industry itself to develop and popularise new uses for its products that, not only have the plants been kept in operation, but extensions have been made.

From time to time during the last decade we have published reports on the progress being made, together with articles dealing with the application of aluminium in many fields. A survey of these provides ample evidence of the ubiquity of the metal and its alloys, and the Exhibition will give engineers and the public an opportunity to see what aluminium has done, and, even more important, what it can do in the future. The record of a century of British progress will undoubtedly point the way to a future which will see even more spectacular advances in much less time than a hundred years.

Birmingham College of Technology

Diamond Jubilee Celebrations

At a recent celebration of the Diamond Jubilee of the College of Technology in Birmingham, emphasis was laid on the close relationship between the teaching of technology and the industry of the Midlands. The occasion was that of the conferment of Honorary Associateships of the College on five men who have risen to control some of the largest industrial organizations in Britain—two of whom were themselves trained in technical colleges—and the awarding of Associateships of the College of Technology to 128 men and women working in Midland industry who have completed to high standards schemes of advanced study in the several departments of the College.

The presentations took place at the Town Hall in Birmingham before a large audience of industrialists connected with the College of Technology, representatives of the city, of the University of Birmingham, and of other technical colleges in the locality.

Technological Education Progress

In his statement before the presentation of the awards, Principal Wilson referred to the dynamic state of technological education at the present time. But he added that "The extension of knowledge and its application cannot stand alone as the guiding motives for an institution such as ours. It is more likely, I suggest, that a student well qualified academically may be a failure, not because he has studied books much, but because he has not studied men more." Thus the development of teaching of personal and human relations aspects of working in industry was having the earnest attention of himself and his colleagues. He went on to warn against "the danger of specialization by well qualified people in a comparatively narrow field of application of technological knowledge; the tendency is to produce at its worst a perverted vision in which the life of the anthill is mistaken for the world at large. Correctives are wide contacts with fellow students, and with people in the industrial environment, and for the student himself to be larger than his speciality, such as may emerge through a broad-based course in fundamental sciences and humanistic studies."

It was for this purpose that the new Sandwich Courses in technology had been launched by the College in all its main departments, which enabled company-sponsored men to attend for full-time courses in the College for six months of each year alongside six months spent in their company's workshops. Already "One company has placed its faith in these courses by arranging for 80 to 100 selected electrical engineering apprentices each year from all its constituent factories to receive their education at Birmingham." Principal Wilson also outlined the very close relationships which exist between the Heads of the College and local companies. It was a result of discussion of this kind that "my Heads have unanimously agreed that automation, servo-mechanisms and automatic control systems are so closely bound up with productivity, that the possibility must be visualised of setting up an entirely new department of study to promote development of these techniques in industry and train the technologists to design, apply and run automatic production units."

Principal Wilson went on to refer to the new branches of technology which lie ahead, and which must be catered for in the new buildings at Gosta Green which will shortly be taken over by the College of Technology. While the existing buildings had been planned, not without imagination, in the bicycle and steam carriage age, the new facilities must serve the new industrial age in dealing with the problems of nuclear energy, automation, electronics, plastics, gas turbines, transistors, and many other new branches of applied science at present in the development stage.

New College Buildings

At a Diamond Jubilee Luncheon after the presentation ceremony, the Chairman of the Governing Body, Mr. J. J. Gracie, welcomed a number of distinguished people who had come to take part in the proceedings, including the Lord Bishop of Birmingham; Mr. F. Bray, Permanent Under-Secretary to the Minister of Education; and the Vice-Chancellor of the University of Birmingham. Mr. Grace said: "Our ambitions are simple, Birmingham is the heart of the British engineering industry, and the College of Technology is the heart of technological training in Birmingham. By a process of extremely simple reasoning it follows that this College should be the greatest engineering training college in Britain—and your Governing Body will not be satisfied until that ambition has been attained."

"We have complete confidence in the fact that, if we are given adequate facilities, we have the men for the jobs. It is notorious that this building and its facilities and equipment are hopelessly inadequate, even for our present teaching requirements; but this possibility was foreseen as long ago as 1933 by a long-sighted City Council, and their plans are now taking shape in the form of the new College Buildings at Gosta Green.

Principal Wilson referred this morning to the origins of the building we are now in, and to the "lean-to" type of mind. If we are not careful our successors, fifty years from now, may say precisely the same things about us. New technologies, just as new, as wide, and as demanding in teaching facilities, as the internal combustion engine was 60 years ago, are with us today—and the programmes evolved in 1933 are already out of date. There is the distinct possibility that the facilities of the new buildings at Gosta Green will be inadequate even before we go into them."

Honorary Associates

At the presentation ceremony, the Honorary Associateship of the College was conferred upon:—

Sir Leonard Percy Lord, Chairman of the British Motor Corporation;

Sir Frederick Handley Page, C.B.E., Chairman of Handley Page, Ltd.;

Mr. A. B. Waring, Chairman and Managing Director of Joseph Lucas, Ltd.;

Lt. General Sir Ronald Weeks, C.B.E., Chairman of Vickers, Ltd.;

Mr. T. Williamson, General Secretary of the National Union of General and Municipal Workers;

and upon Dr. James C. Duff, former Head of the Department of Chemistry in the College.

New Bar Heat Treatment Plant

Sanderson Brothers and Newbould Modernisation

General view of the heat treatment shop.

IN order to facilitate the production of alloy steel bars heat treated to customers' requirements, Sanderson Brothers & Newbould, Ltd., have recently modernised their heat treatment plant. Four solid fuel fired furnaces have been replaced by town's gas fired furnaces.

The new plant, which came into operation early this year, comprises two hardening furnaces and a tempering furnace, an oil quenching unit, a water quenching unit, and a revolving floor-type charging machine. Fuel Furnaces, Ltd., of Birmingham, as general contractors, were responsible for the design and building of the furnaces and for the installation of the equipment. Sanderson's Engineers' Department laid the foundations and carried out other preliminary work.

Hardening

The hardening furnaces have working chambers 5 ft. wide × 1 ft. 9 in. high × 16 ft. 6 in. long, and are capable of treating a charge of up to 3 tons. They are built on the underfired principle and the products of combustion are induced downwards through the load to give balanced even heating. For temperature control purposes, each furnace is divided into two zones. The proportional gas-air temperature control system is used, each furnace being equipped with 30 burners having measuring jets for both the gas and air. The waste heat from the furnace is used to preheat the combustion air by means of a recuperator in the arch and side walls. The hearth is specially constructed with three slots for the reception of the arms of the charging machine, and the door is operated by means of compressed air.

Tempering

The tempering furnace, built on the overfired principle, is designed for high velocity circulation of furnace gases at temperatures up to 700° C. When working at higher temperatures, up to the maximum of 850° C., circulation is induced, as in the high temperature furnace. If desired, the recirculating fans can be arranged to cut out automatically on the temperature reaching 700° C., and to re-start when the temperature falls below that figure.

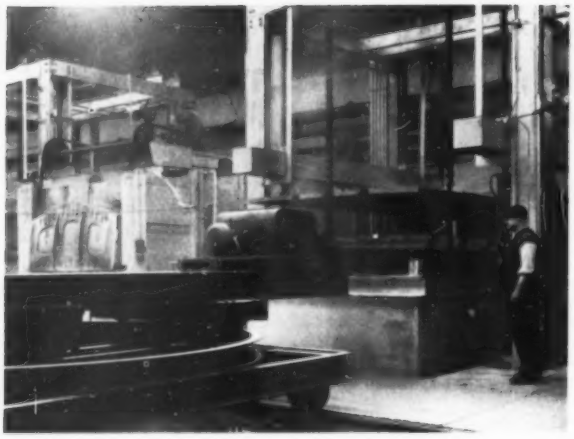
In normal tempering operations, which are, of course, carried out below 700° C., the combustion gases re-circulate through the load and hearth at high velocity, passing through ports situated between the burner ports. Eight horizontal-type nickel-chromium centrifugal fans, operating in cast iron collecting chambers below the hearth, draw the furnace gases through the load, and re-inject them into the work chamber. Besides tending towards a more even temperature, this recirculation of gases also enables the excess waste gases to be used as a frontal curtain to prevent ingress of air through the door, thereby reducing oxidation.

There are 30 burners, each having identical jets for gas and air. As in the case of the hardening furnace, these are divided into two zones for temperature control purposes. The working chamber dimensions are identical with those of the high temperature furnace.

It has been stated that the furnaces are designed for proportional gas-air temperature control. For this purpose each furnace is divided into two zones, front and rear, with a pyrometer to record the temperature in each, the thermo couples being inserted through the roof. A control panel carries the six Kent Multelec temperature recorder controllers and ancillary equipment.

Quenching Units

The reciprocating oil quenching machine has an oil capacity, under working conditions, of approximately 4,300 gallons. This machine consists of a rectangular tank with cover and a substantial steel table to hold the bars. On the bars being placed on the steel table by the charger, the table, pneumatically-operated, is allowed to sink into the tank, and the cover is automatically lowered into position. The quenching table, with bars, is moved up and down in the tank by four pneumatic cylinders and counterbalance gear, the action being continued until completion of quenching. The oil is continuously circulated during quenching by an electri-



Bars on table of oil quenching machine.

cally-driven propeller-type circulating gear. It is also pumped through a Serck cooler installed at the rear of the quenching unit to prevent overheating of the bath during quenching.

The water quenching unit is similar in general construction to the oil quenching unit, but is not provided with cover or circulating gear. Circulation is effected by pumping cold water through the tank and thence to drain. River water, being cheap and plentiful, is normally used, but an emergency supply of town's water is also available.

Charging Facilities

Two pre-fabricated steel loading tables are provided for building up the charges of bars. One table is adjacent to the hardening furnaces, the other to the tempering furnace. Construction of the tables allows for insertion of the arms of the charging machine. Bars are conveyed to the table by overhead crane.

The charging machine, for operating in conjunction with the furnaces, the quenching machines and the tables for loading and unloading of the bars, is of the rotary type, and is arranged to travel across the front of these units in order to load or unload them in one movement. It is provided with three arms having a travel of 18 ft., formed from two separate horizontal members one above the other, to enable the load to be lifted, the arms to be deposited without shock, and, finally, the arms to be withdrawn. The three movements of lift, charge and travel are each driven by separate motors with full control, the arm travel and the rotation being interlocked so that the machine cannot be rotated unless the arms are fully withdrawn.

Heat treatment shop instrument panel.

European Statistical Quality Control Conference

The first European Conference on Statistical Quality Control will be held in Paris from the 11th to 13th July. To the Conference, which is sponsored by the European Productivity Agency of the Organisation for European Economic Co-operation, will come statistical quality control experts from Belgium, France, Germany, Italy, the Netherlands, Sweden, the United Kingdom and the United States.

Statistical quality control, one of the most recently developed techniques of industrial management, has quickly gained prominence in modern industrial life, as it contributes towards lowering costs and improving the quality of products. Lectures will be given on such subjects as the use of statistical quality control in management, training and experimentation, and its technical applications in industry, and texts will be sent to the participants prior to the conference. The European Productivity Agency, in organising this first international conference on statistical quality control, is fulfilling one of its aims, which is to enable highly qualified technicians from different countries to exchange their views and debate problems of common interest.

Further details on the conference and the complete programme may be obtained from national productivity centres or direct from the European Productivity Agency, (Project 328), 3, Rue André Pascal, Paris, 16e.

A.D.A. President

At the Annual General Meeting of The Aluminium Development Association, held in London on April 22nd, Dr. Horace W. Clarke, Chairman and Managing Director of James Booth & Co., Ltd., was elected President. He was one of the founders of the development organisation, which was created in 1941, and when it was absorbed by the present Aluminium Development Association ten years ago, he became its first President. He has again been elected to hold this office in the centenary year in Britain of aluminium as a commercial metal. The Hon. Geoffrey Cunliffe, Deputy Chairman and Managing Director of The British Aluminium Co., Ltd., was elected Vice-President of the Association.

Tendering for Copper

The Board of Trade announce that they invite tenders for the sale of 15,000 tons of electrolytic copper for pricing and delivery over five months beginning in June. Applications for tender forms should be made to the Board of Trade (Room 3166) Horse Guards Avenue, Whitehall, London, S.W.1. This quantity forms part of the unsold balance (about 28,000 tons) of the 45,000 tons of electrolytic copper, the impending sale of which was announced by the Board of Trade on April 13th. The remaining 13,000 tons will be offered for sale later.

A Survey of Metallurgical Films

By J. P. Moore, A.I.M., A.M.I.M.M.

The popularity of film evenings in many technical societies and the growing use of the film as a means of instructing students have prompted the publication of this survey, in which the author outlines the principal features of a number of films of metallurgical interest which are available for loan or hire.

DURING recent years a considerable number of films of interest to metallurgical audiences have been made or released in this country—some general in their subject matter, others more restricted in their presentation—and it is proposed to consider available films according to the main divisions of the technology. Not all the films available for loan or hire will be discussed, the survey being restricted to those which have been found to be most suitable by virtue of their modern treatment, clarity and conciseness, or discretion in the use of advertising matter.

Most of the films to be discussed are the products of industrial organisations, and have a publicity viewpoint which is expressed to varying degrees. Most of the modern industrial films are, however, much more discreet in the matter of advertising than were their predecessors, and some producers would appear to depend for their publicity on the quality of the film itself, with scarcely more than a mention of the parent organisation in the credit titles.

List of Suppliers

The following is a list of the main suppliers of metallurgical films, in particular, those issuing a catalogue. These organisations loan their films quite freely, with the exception of the Central Film Library and the Educational Foundation for Visual Aids, who hire out films on a daily charge rate.

The British Iron and Steel Federation, Training Department, Windsor House, 46, Victoria Street, London, S.W.1, issues a free catalogue, "Visual Aids," and loans films on ferrous metallurgy on request.

The Central Film Library, Government Building, Bromyard Avenue, Acton, London, W.3, issues a catalogue of industrial films, "Films for Industry," price 1s. 6d. The Library films may be hired at rates dependent upon the film and period required.

The United States Operations Mission to the United Kingdom, American Embassy, 5, Grosvenor Square, London, W.1 issues a free catalogue, "Industrial Films," comprising 149 titles offered on free loan through O.E.E.C. to the U.K.

The Aluminium Development Association, 33, Grosvenor Street, London, W.1, issues a free list of publications and films, and loans the films free to members and non-members of the Association.

The Mond Nickel Co., Ltd., Publicity Department, Thames House, Millbank, London, S.W.1, issues a list of visual aids obtainable on free loan, which includes nine films.

The Petroleum Film Bureau, 29, New Bond Street, London, W.1 issues a free catalogue of documentary and instructional films which may be borrowed without charge.

The following organisations also issue lists of films available for free loan:

The Copper Development Association, Kendals Hall, Radlett, Herts.

Metropolitan Vickers Electrical Co., Ltd., Publicity Dept., Trafford Park, Manchester, 17.

Several films suitable for showing to metallurgical audiences are available for hire from:

The Educational Foundation for Visual Aids at 33, Queen Anne Street, London, W.1.

The films to be surveyed are classified according to the subject matter. This is not an absolute classification, however, as several of the films could be included in other categories than the ones chosen. The Miscellaneous Section is included to provide for films of ancillary interest relevant to the wide field of metallurgy. All those chosen are 16 mm. (some are also available in 35 mm.), sound films in black and white, unless otherwise stated as being in colour, and the cost of hiring is shown as the rate for one day's hire. The address of the source from which a particular film may be borrowed is given only in the case of those organisations not included in the above lists.

Properties, Structure, Examination and Testing of Metals and Alloys

The Microscopy of Opaque Objects (14 minutes). Free loan from Petroleum Film Bureau.

The Phase Contrast Microscope (23 minutes). Free loan from Cooke, Troughton & Simms, Ltd., Broadway Court, Westminster, S.W.1.

The Electron Microscope (18 minutes). Free loan from Metropolitan-Vickers Electrical Co., Ltd.

The Bubble Model of a Metal (17 minutes). Free loan from Macqueen Film Organisation, West Street, Bromley, Kent.

The Problem of Creep in Metals (colour) (16 minutes). Free loan from Mond Nickel Co., Ltd.

X-Ray Crystallography (In Preparation). Educational Foundation for Visual Aids.

Hardness Testing (Rockwell) (18 minutes). 10s. fee, from Central Film Library.

The microscopical examination of metals is not studied specifically in the three films on microscopy, but the principles of the optical microscope are outlined by *The Microscopy of Opaque Objects*, which also shows the correct use of the instrument so as to achieve the best results. A specialist use of the optical microscope is very well illustrated in *Phase Contrast Microscopy*. This film shows how changes of phase are transformed into changes in amplitude, thus yielding a contrasted monochromatic image in which the light distribution is related to the phase change. The film graphically illustrates this by means of animated diagrams, and shows the setting up and practical application of the phase contrast microscope with both transmitted and incident light. This is essentially a film for advanced students of metallography, who may be judged capable of translating

these optical principles into metallographic application.

The Electron Microscope illustrates the basic technique required in the preparation of different types of specimen for examination, and shows examples of the structures obtained, all illustrated by demonstration and animated diagrams. The basic features of the Metrovick EM3 instrument are shown, and the possible developments surveyed.

The Bubble Model of a Metal is a new sound production of the bubble model, which was hitherto demonstrated in a silent film available from the Central Film Library. The behaviour of the bubble-raft under deformation is presented by Sir Lawrence Bragg and simulates the origin and movement of dislocations in metal crystals. The behaviour of like and unlike dislocations is shown, as well as the influence of vacant lattice sites and stranger atoms, the latter represented by bubbles of non-uniform size. The illustration is graphic and the judicious use of repetitive sequences makes the mechanism obvious.

The Problem of Creep in Metals discusses the phenomenon of creep, showing by means of diagrams the distinction between tensile straining, as in the tensile test, and the strain resulting from continuous loading, particularly at high temperatures. The implications of the creep curves and types of testing are discussed, and their applications in practice are illustrated with reference to the Nimonic alloys. The colouring of the film is occasionally confusing, the coloured diagrams being difficult to read, but the film is very useful, if only to show the distinction between short-term and long-term testing, and the interpretation of the results.

X-ray Crystallography, still in preparation, will be issued by the Educational Foundation for Visual Aids, and is to be presented by the General Electric Co., Ltd. This will be an addition to the Advanced Science Series, which consists of films designed especially as teaching aids. Those already available are of a very high standard, and if this current film reaches that same standard, it will be of great value.

Hardness Testing (Rockwell) is a short film on the Rockwell hardness tester, illustrating the use and applications of the instrument. Reference is also made to the checking and testing of the machine. Whilst this is an elementary film in its subject matter, it is, nevertheless of value in illustrating the operation of the tester.

Corrosion and Protection

Corrosion in Action (colour) (64 minutes). Free loan from Mond Nickel Co., Ltd.
Must it Rust (20 minutes). Free loan from Zinc Development Association, 34, Berkeley Square, London, W.1.
Steel Plus (40 minutes). Free loan from United States Operations Mission.
Pattern for Progress (47 minutes). Free loan from Richard Thomas & Baldwins, Ltd. Publicity Department, 47 Park Street, London, W.1.
Metal Spraying (32 minutes). Free loan from Metallisation, Ltd., Barclays Bank Chambers, Dudley, Worcs.
Stainless Steel (27 minutes). Free loan from United States Operations Mission.

Undoubtedly one of the best technical instructional films available, *Corrosion in Action* illustrates in clear simple stages the mechanisms of corrosion and the controlling electro-chemical principles. Animated diagrams indicate the ionic behaviour within the cells representing galvanic couplings, and the control of the operating mechanisms is shown by the behaviour of suitably chosen couplings. The film is happily divided into three reels, each of which can be shown separately, the reel contents being as follows: (*a*) principles, polarisation and aeration; (*b*) galvanic coupling, control of current corrosion products; and (*c*) passivity and protection crevice corrosion and shielding.

Must it Rust could be a useful film dealing with galvanising by the hot-dip process, and the application and usefulness of the galvanised products, but the commentary is not worthy of the presentation and tends to be irritating. This film might be watched with the sound turned down and the commentary given after a preview by one of the show organisers.

Steel Plus and *Pattern for Progress* are two films illustrating tinplate production, the one American, the other British (made at Richard Thomas & Baldwins' Ebbw Vale plant). Each film covers similar topics, starting with iron and steel making, followed by rolling, pickling and the finishing coating trains. Both are excellent productions giving a very good view of the strip rolling and plant operation.

Metal Spraying by the Wire Process is a useful film showing the application of sprayed metal coatings to effect surface protection, including protection against high temperature oxidation. The operation of the spraying pistol is shown and both metallic and non-metallic applications are portrayed.

Stainless Steel presents what is, metallurgically, a somewhat elementary treatment of stainless steel. Nevertheless, it is a very useful film because of the wide treatment of the subject. The constitution of stainless steel is explained and the manufacture of strip, plate, bar and wire is illustrated.

Foundry Practice

Foundry Practice (26 minutes). Free loan from Babcock & Wilcox, Ltd., Publicity Department, Babcock House, Farringdon Street, London, E.C.4.
Steel Horizons—Sand and Steel (24 minutes). Free loan from United States Operations Mission.
Introduction to Die Casting (colour) (26 minutes). Free loan from United States Operations Mission.
The Shortest Way (26 minutes). 15s. fee, from Central Film Library.
Precision Investment Casting (10 minutes). 5s. fee, from Central Film Library.

In addition to this specialised selection of films on casting practice, the current industrial film catalogue of the Central Film Library carries an imposing list of films devoted to various aspects of this subject. These films are extremely specialised, but some idea of their coverage can be gained from the following classification: handling (1 film); cupola operations (2 films); bench moulding (5 films); floor moulding (5 films); machine moulding (2 films); core making (1 film); gating (1 film); and pattern making—fundamental operations and modifications (17 films). Reference to the catalogue will suggest which are the most suitable films for any specific purpose. The general selection at the beginning of this section, however, presents various aspects of casting techniques, and is suitable for non-specialist audiences.

Foundry Practice is an excellent introductory approach to the subject, indicating the basic processes of pattern making, sand moulding, and core making. In simple detail, the stages of production in bench moulding are illustrated, followed by pouring and breaking out of the casting. *Steel Horizons—Sand and Steel* deals with the production of stainless steel castings, showing the production of sand moulds and cores and the placing of patterns. The removal of simple and intricate patterns

is illustrated, and the film concludes with the pouring, removal of the castings, and the subsequent testing by hydrostatic and radiographic techniques.

Pressure die casting is considered in the two films *Introduction to Die Casting* and *The Shortest Way*, although the treatment is very different. The former is the simpler of the two productions, dealing with the development of the process and illustrating the die casting machine by animated diagrams. The second film is more a broad survey of the scope of the process, and of the use of the various alloys of zinc, aluminium and magnesium, with reference to the operating techniques in use. Both films could probably be shown in the same programme with advantage.

Precision Investment Casting presents, in the space of only 10 minutes, a good review of the wax pattern process. The treatment is presented in a clear, simple fashion, illustrating the stages of the process and the production of some few components.

Extraction of Non-Ferrous Metals

Story of an Ore Sample (colour) (40 minutes). Free loan from Cyanamid Products, Ltd., Bush House, Aldwych, London, W.C.2.

This is Aluminium (28 minutes). Free loan from Aluminium Development Association.

This is Magnesium (12 minutes). Free loan from United States Operations Mission.

Nickel Extraction by the Mond Process (17 minutes). Free loan from Mond Nickel Co., Ltd.

Extraction of Precious Metals from Ni–Cu Ores (colour) (26 minutes). Free loan from Mond Nickel Co., Ltd.

Zinc Mining, Milling and Extraction (25 minutes). Free loan from Zinc Development Association, 34, Berkeley Square, London, W.1.

Copper Mining, Ore Dressing, Smelting and Refining in N. Rhodesia (50 minutes). Free loan from Copper Development Association.

Cyanamid Products, Ltd., loan *Story of an Ore Sample*, which covers the laboratory and pilot plant dressing of an ore sample to determine its content and response to ore dressing. Treatments shown include the use of a heavy media separator, violet emission spectroscopy, and microscopical examination of prepared samples. Flotation testing and cyanidation are presented as part of the testing programme, and the film ends with the compilation of a report on the original ore sample.

This is Aluminium is an extremely useful film in illustrating the extraction of aluminium. The mining of the bauxite is shown, followed by the subsequent preparation from it of alumina. After suitable screening, washing and drying, the conversion to sodium aluminate in the course of alumina preparation is demonstrated. Finally the production of the aluminium metal in the electrolytic cell is portrayed, the process being very well illustrated both by diagrams and actual scenes in the plant.

This is Magnesium presents a picture, in outline, of the process of magnesium extraction from sea water. The film shows the stages in this process—the precipitation of magnesium hydroxide, the thickening, filtering and neutralising, and the decomposition of the magnesium chloride by electrolysis. Some of the final sequences are devoted to the mill processing, and the working, welding and riveting of the metal.

An extremely valuable description of the Mond carbonyl process operated at Clydach, South Wales, is available in *Nickel Refining by the Mond Process*. In some detail the operation of the refining towers is shown, good use being made of animated diagrammatic sequences to show the reactions within the towers. The subject matter is presented in a very clear and concise fashion. From the same source, *Extraction of Precious Metals from Nickel-Copper Ores* is an extremely concentrated illustration of the extraction of the platinum group metals from the residues of nickel ores. So concentrated is this presentation that many of the audience will, undoubtedly, lose track of the processing. Unfortunately, the subject matter does not lend itself to elaboration, and it is difficult to visualise how the extraction of seven different metals could be presented other than by the sequential treatment offered here. However, good use is made of the colour presentation of the salts and solutions, and flow sheet diagrams are frequently employed.

Zinc—Mining, Milling and Extraction, as its title suggests, is concerned with the extraction of zinc, and surveys the mining and subsequent dressing of the ore, followed by the extraction of the metal from the concentrates.

Copper Mining, Ore Dressing, Smelting and Refining in N. Rhodesia is a long film, but very well produced, dealing with the extraction of copper, all the stages being reviewed, from the prospecting to the smelting and refining operations. The objects and practice in each of the operations are clearly illustrated, and the film is useful in indicating general extraction practice in addition to the specialised treatments for copper.

A classified list of 72 films on metal mining and allied subjects is available from The Institution of Mining and Metallurgy, price 1s.

Iron and Steel Making

Steel (colour) (35 minutes). Free loan from British Iron & Steel Federation.

Right Material in the Right Place (20 minutes). Free loan from United States Operations Mission.

Eternally Yours (22 minutes). Free loan from United States Operations Mission.

What Goes Into the Blast Furnace (15 minutes). Free loan from British Iron & Steel Federation.

Making Iron (15 minutes). Free loan from British Iron & Steel Federation.

What Comes Out of the Blast Furnace (8 minutes). Free loan from British Iron & Steel Federation.

The Open Hearth Furnace—I (13 minutes). Free loan from British Iron & Steel Federation.

The Open Hearth Furnace—II (12 minutes). Free loan from British Iron & Steel Federation.

Furnace Control (14 minutes). Free loan from British Iron & Steel Federation.

Electric Furnaces (14 minutes). Free loan from British Iron & Steel Federation.

The Ingot (15 minutes). Free loan from British Iron & Steel Federation.

S.G. Iron—Cast Iron that Bends (15 minutes). Free loan from Mond Nickel Co., Ltd.

A good general introduction to the steel industry is provided by the colour film *Steel* which, in a most attractive manner, both visually and factually, presents the story of the manufacture of steel and its subsequent manipulation. The subject matter includes the mining of the ore and blast furnace operations, followed by the subsequent manufacture of steel by the Bessemer, electric arc, and open hearth processes. Mechanical treatment includes rolling, drop stamping and the production of large scale press forgings.

Right Material in the Right Place is somewhat similar in treatment, briefly summarising the various stages in the manufacture of iron and steel. In addition to the production of pig iron, the film also deals with the manufacture

of wrought iron, cast iron and the malleable irons. Subsequent sections illustrate the production of steel by the Bessemer and open hearth processes, and the rolling of merchant stock. The film commentary is somewhat disjointed, and sounds as though a British commentary had been dubbed on to the original film after crossing the Atlantic.

The production of wrought iron by the Byers' process is illustrated by the film *Eternally Yours*, the whole train of operations from pig iron to manufactured products being shown. The reverberatory furnace practice is well illustrated, and suitable emphasis is laid upon the control of the processing. Final sequences demonstrate the production of wrought iron pipe.

The British Iron and Steel Federation have issued a series of three films on iron making, and a further five on steel making, the titles of which are presented in the selection at the head of this section. These short films were produced to aid students for the City and Guilds Iron and Steel Operatives' course, but are worthy of a wider audience. Technically, they are excellent, and present their subject matter in a clear and concise fashion. The three on blast furnace practice, *What Goes into the Blast Furnace*, *Making Iron*, and *What Comes out of the Blast Furnace*, have as their subject matter the following: firstly the treatment of the ore, coke oven practice and the operation of the hot blast stoves; secondly, the charging of the furnace, its design and operation, and the smelting processes; and thirdly, the tapping of iron and slag, and the cleaning of the blast furnace gas. All three films freely employ the use of animated diagrams to illustrate the operations and the reactions.

The five films on steel making can be divided into two groups: three deal with open hearth furnace operation and control. *The Open Hearth Furnace—I* describes how the furnace works, entailing a study of its construction, the regenerative system, and the layout of ancillary plant in the melting shop. *The Open Hearth Furnace—II* is concerned with the charging and operation, including the reactions, which are explained by the use of simplified animated sequences. The function of the slag is described and the differences between acid and basic furnaces outlined. The third film deals with *Furnace Control*, being concerned with the control instrumentation affecting roof temperature, furnace pressure and gas/air flow.

The two remaining films are entitled *Electric Furnaces* and *The Ingot*. The former deals with the construction and operation of the electric arc furnace and the high-frequency induction furnace, animated diagrams being used to illustrate the chemical reactions and operating mechanisms. The latter film compares the different methods of teeming ingots, including killed, unkilled and semi-killed ingots, and explains the purposes for which each type is generally used.

S.G. Iron—Cast Iron That Bends is a newly-produced film, and deals with the properties and engineering applications of this new type of cast iron.

Working and Welding

Forging—II (40 minutes). Free loan from High Duty Alloys, Ltd., Publicity Department, Slough.

Forging (30 minutes). Free loan from Babcock & Wilcox, Ltd., Publicity Department, Babcock House, Farringdon Street, London, E.C.4.

Wire (40 minutes). £1 fee, from Central Film Library.

Manufacture of Stainless Strip (colour) (20 minutes). £1 fee, from Central Film Library.

Streamlined Steel (28 minutes). 15s. fee, from Central Film Library.

Copper and its Alloys (colour) (23 minutes). Free loan from United States Operations Mission.

Aluminium Tubes and Extruded Shapes (colour) (18 minutes). Free loan from Aluminium Development Association.

Fabrication of Aluminium Alloys (20 minutes). Free loan from Aluminium Development Association.

Seamless Tube Making (17 minutes). Free loan from Babcock & Wilcox, Ltd., Publicity Department, Babcock House, Farringdon Street, London, E.C.4.

Walls Without Welds (25 minutes). 10s. fee, from Central Film Library.

E.R.W. (31 minutes). Free loan from Stewarts & Lloyds, Ltd., Publicity Department, Brook House, Upper Brook Street, London W.1.

Through the Mill (30 minutes). Free loan from Stewarts & Lloyds, Ltd., Publicity Department, Brook House, Upper Brook Street, London, W.1.

Welded Line Pipe (17 minutes). Free loan from United States Operations Mission.

Argon Arc Welding (57 minutes). Free loan from Aluminium Development Association.

This is Resistance Welding (28 minutes). Free loan from United States Operations Mission.

Atomic Hydrogen Arc Welding (18 minutes). 10s. fee, from Central Film Library.

Oxyacetylene Flame (18 minutes). 10s. fee, from Central Film Library.

Split Second Fastening (12 minutes). 5s. fee, from Central Film Library.

The Welding of High Nickel Alloys (26 minutes). Free loan from Mond Nickel Co., Ltd.

The Manipulation of Corrosion and Heat Resisting Steels (66 minutes). Free loan from Firth-Vickers Stainless Steels, Ltd., Publicity Department, Sheffield.

The two films entitled *Forging* are respectively concerned with the forging of light alloys and the forging of steel. The H.D.A. film concerns itself with the shaping of both large and small components in light alloys, whereas the film from Babcock & Wilcox traces the development of the process from hand forging in the smithy to the heavy forging in a modern steel works.

Wire gives a general review of the manufacture of wire and wire products, the processes of rolling, pickling, drawing, patenting, high speed drawing and subsequent annealing, galvanising and testing being illustrated. The film also includes valuable sequences on the design and preparation of tungsten carbide dies.

The Manufacture of Stainless Strip is a vivid colour presentation of the processing of stainless steel ingots into strip, concerning itself with the rolling, coiling and annealing for further working, followed by the pickling process, which is illustrated in some detail. *Streamlined Steel* is also concerned with rolling into strip, and considers in some detail the rolling of the ingots together with the ancillary operations of control and subsequent testing of the product.

Copper and its Alloys deals with the fabrication of copper and its alloys, with particular reference to brass. The following processes are very well illustrated: casting; rolling into sheet; production of seamless tubes by hot piercing and extrusion; extrusion of rod; and rolling of rod and bar.

The general fabrication of aluminium alloys is featured in the two films *Aluminium Tubes and Extruded Shapes* and *Fabrication of Aluminium Alloys*. The former, in pleasing Kodachrome, deals with the semi-continuous casting of billets, the extrusion of tube blooms and reeling, followed by tube reducing by both machine and bench drawing, and some suitable applications of such stock. The second film deals with the casting of billets, followed by the rolling of sheet, strip and special sections. Some rolling of foil is illustrated, as is also extrusion and impact extrusion, forging, pressing and routine testing.

Seamless tube manufacture is represented by the two films *Seamless Tube Making* and *Walls Without Welds*. The first film illustrates the production of tube by rolling and Pilger mill processing, together with subsequent draw bench and reducing mill operations, the Pilger mill sequences being extremely well done. The second film is somewhat similar in technique, dealing with the production of both seamless pipe and tube, and involves the rolling and piercing of bar, and the reduction of wall thickness in subsequent processing, followed by testing of the cooled straightened pipe.

E.R.W. concerns itself with the electric resistance welding process for the production of steel tube, in which cold rolled steel strip is formed into a cylinder and the cutting edges joined by resistance welding. Stewart & Lloyds also loan *Through the Mill*, which deals with the whole processing of steel into tube. Some early sequences are devoted to the making of iron and steel, but the film is primarily concerned with the manufacture of seamed and seamless tubes.

As distinct from tube manufacture, *Welded Line Pipe* shows the fabrication of large line pipe. In this film, the "skelp," after suitable pickling and trimming, is formed into pipe and flash welded in large welding machines. The pipe is then trimmed and the ends expanded and machined, followed by external sizing using water at great pressure; the whole process is illustrated by animated diagrams.

Argon Arc Welding is in two parts. Part I deals with the process, the equipment, and its application in the welding of alloys where surface oxide films would normally interfere with the welding process. Part II relates to the argon arc welding of aluminium, and demonstrates graphically, by means of high speed photography, the use of the inert gas shield to protect the weld pool from oxidation, whilst the ionic transport of the arc disperses the oxide film present so that a sound weld results.

Atomic Hydrogen Arc Welding illustrates the elements of the process, and explains the operation and control by means of diagrams. Also featured are examples of typical jointing techniques. *Oxy-Acetylene Flame* shows the use of the oxy-acetylene torch in both its welding and its flame cutting applications. The processes illustrated range from the welding of plate to brazing, and the film demonstrates the repair of castings together with the welding of grey cast iron.

This is Resistance Welding describes the three types of resistance welding—spot, projection and seam—pointing out the advantages and applications of each type. The treatment is somewhat over long but, nevertheless, it is a useful film.

Split Second Fastening is concerned with the technique and applications of stud welding, the welding gun being described in some detail. Various applications are illustrated and the film makes its point in a short and concise manner.

The Welding of High Nickel Alloys is a useful film describing the various methods and techniques for the welding of nickel, Monel and Inconel alloys. A reasonable familiarity with normal welding techniques is assumed, but this is not unreasonable in a short film of this nature. On the other hand, *The Manipulation of Corrosion and Heat Resisting Steels* is rather a long film, and in places tends to drag somewhat. It deals in Part I with welding techniques suitable for these steels, illustrating most of the methods with do's and don'ts. Part II restricts itself to fabrication techniques, such as machining, pressing and polishing, again indicating the precautions to be observed.

Heat Treatment

Heat Treatment of Steel—I (18 minutes). Free loan from United States Operations Mission.

Heat Treatment of Steel—II (15 minutes). 10s. fee from Central Film Library.

Heat Treatment of Steel—III (14 minutes). Free loan from United States Operations Mission.

Radio Frequency Induction Heating (9 minutes). Free loan from United States Operations Mission.

Budd Induction Heating—Tocco (internal) (14 minutes). Free loan from United States Operations Mission.

Formation of Bainite (17 minutes). Free loan from British Iron & Steel Research Association, 11, Park Lane, London, W.1.

Heat Treatment of Aluminium—I (20 minutes). Free loan from Aluminium Development Association.

Heat Treatment of Aluminium—II (23 minutes). Free loan from Aluminium Development Association.

Powder Metallurgy (19 minutes). 10s. fee, from Central Film Library.

Powder Metallurgy—II (15 minutes). 10s. fee, from Central Film Library.

The series of three films on *Heat Treatment of Steel* were produced by the U.S. Office of Education, and employ American steel specifications in their illustrations, but the treatment, although elementary, is useful. The first film concerns itself with the quench hardening of steel, and compares the results, in terms of structure and hardness, of the treatment of a range of carbon contents. The second film shows the structural changes at progressive tempering stages. The correlation of toughness/hardness during this operation is indicated, as are the effects of normalising and annealing. The third film is, undoubtedly, the most useful of the series, reviewing as it does, in a masterly fashion, the elements of carburising, nitriding, and flame and induction hardening in the short space of 14 minutes.

The two films on induction hardening are valuable in their illustration, not only of the process, but also of the production line technique which may be adopted using these techniques. *Radio Frequency Induction Heating* illustrates applications involving the heating of small parts, such as the treatment of hack-saw blades and the annealing of the heads of pins used on chain belts. *The Budd Induction Heating Process* deals with the internal heat treatment of various hollow components, illustrating the control of the process in order to treat selectively splined, tapered or straight bores. Visual aids incorporated include the use of animated drawings and the treatment of a glass cylinder to demonstrate the action of the quench head and heating head.

The Formation of Bainite is a production designed to demonstrate the transformation of austenite, and incorporates sequences produced by the University of Birmingham Research Team. These sequences, using high speed ciné photomicrography with hot stage techniques, graphically illustrate the transformation of austenite to bainite by a coherent nucleation process, and the transformation to martensite by a sudden overall process, no nucleation and growth being visible.

The two films on the *Heat Treatment of Aluminium* are somewhat elementary, but, nevertheless, serve as a suitable introduction to the subject. The first film deals with the structural changes resulting in a polygonal-grained structure as a result of deformation and recrystallisation. The structure and property changes as a result of quenching and ageing treatments are illus-

trated by means of diagrams and photomicrography. The second film discusses the nature of cold working operations and the changes in microstructure resulting from cold work and subsequent annealing operations.

Powder Metallurgy I & II deal, respectively, with the principles and uses of the technology, and the manufacture of porous bronze bearings. The first film reviews the advantages and potentialities of powder metallurgy and gives an illustration of each of these uses : for the combination of metals and non-metals ; for alloying high melting point metals ; and as a manufacturing technique to avoid machining. The film concludes with some sequences illustrating the self-lubricating porous bearing. The second film is concerned with the stages in the manufacture of porous bronze bearings, and illustrates the compacting, sintering, impregnation and finishing of these components. The ease of production is illustrated using a high productivity technique and this film serves as a very good follow up to film I.

Miscellaneous

The Spectrograph (colour) (20 minutes). 30s. fee, from Educational Foundation for Visual Aids.
Friction (20 minutes). 15s. fee, from Educational Foundation for Visual Aids.
Principles of Ultrasonics (15 minutes). 10s. 6d. fee, from Educational Foundation for Visual Aids.
The Linear Accelerator (12 minutes). 7s. 6d. fee, from Educational Foundation for Visual Aids.
Hard Metal (colour) (45 minutes). Free loan from Protolite, Ltd., Central House, Upper Woburn Place, W.C.1.
Coal Cleaning (11 minutes). Free loan from Cyanamid Products, Ltd., Bush House, Aldwych, London, W.C.2.

The above selection of films is included to amplify certain ancillary subjects of interest to most metallurgical audiences. The four films loaned by the Educational Foundation are of recent origin, and constitute part of their Advanced Science Series, designed specifically as instructional films. They have been expertly produced with both scientific and educational advisers and are models of their kind.

The Spectrograph deals with the operation and control of the instrument in the examination of various materials, both metallic and non-metallic in nature. In addition, the film indicates a physical conception of the radiation of atomic energy. *Friction* is presented by Esso Petroleum Co., Ltd., and attempts to illustrate the physical meaning of friction and the effects of correct lubrication. *The Principles of Ultrasonics*, by Mullard, Ltd., gives a clear explanation of the principles of the phenomena of this new science, which is being applied to the soldering of aluminium, the drilling of refractory materials, and the cleaning of parts and delicate mechanisms. Also presented by Mullard, Ltd., *The Linear Accelerator* attempts to explain in non-mathematical terms the process whereby electrons are accelerated to speeds approaching the speed of light by applying a potential of 50,000 volts. These high energy electrons are used in the production of " hard " X-rays for therapeutic and nuclear research.

Hard Metal reviews the processes involved in the production of tungsten carbide, and illustrates the applications of the material in industry, whilst in *Coal Cleaning* a modern technique of coal cleaning by float-sink processes is demonstrated using the link drum separator, the layout and operation of the ancillary plant being also shown. The closing sequences point out the advantages of clean coal for both industrial and domestic use.

In addition to the above films of specific interest, the British Iron & Steel Federation loan a number of well-made documentaries on current activities in the iron and steel industry of which two are presented as examples. *Steel and Atomic Energy* reviews in 16 minutes the contribution of the steel industry to the development of atomic energy power installations, and the part played in the development of this major industry of the future, whilst *The Birth of a Mine* studies the development of the mining of rich iron ores at Conakry in West Africa. The development of this site commenced in 1950, and the process of building and expansion is still continuing by the Compagnie Miniere de Conakry, a joint French and British enterprise.

In concluding this survey of some of the currently available metallurgical films, it should be remembered that the invaluable service rendered by the loaning and hiring associations mentioned above is dependent for its successful continuance upon the co-operation of the borrowers of the films. The service will be assisted greatly if borrowers will always remember three simple points : (*a*) book the films well in advance ; (*b*) take good care of the films ; and (*c*) return them promptly after the showing.

Powder Metallurgy Congress

The Second International Powder Metallurgy Congress, sponsored by Dr. Paul Schwarzkopf, President of The American Electro Metal Corporation, Yonkers, N.Y., will take place in Reutte, Tyrol, Austria, from June 20th to June 23rd. Reutte was again chosen for the seat of this international seminar because Europe's largest powder metallurgy company, The Metallwerk Plansee, is located there.

The theme will be " High Temperature and Corrosion-Resistant Materials by Powder Metallurgy ", and so far some 300 representatives from 17 nations have been registered as delegates, including over 30 scientists, industrialists and engineers from the United Kingdom.

The ferrous powder metallurgy interests of Metallwerk Plansee are represented in this country by George Cohen Sinteel, Ltd., a subsidiary of The 600 Group of Companies.

Birmingham University Metallurgical Society Jubilee

In recognition of the fact that this is its Golden Jubilee Year, the Birmingham University Metallurgical Society is producing a special enlarged magazine in October of this year. The Society would like to send a free copy to any former members, and those wishing to take advantage of this offer are asked to write to the Editor at the Metallurgical Department, The University, Edgbaston, Birmingham 15.

Change of Address

The Zinc Development Association and its affiliates, The Hot Dip Galvanizers, The Zinc Alloy Die Casters and The Zinc Pigment Associations, have removed from their offices in Oxford to new premises at 34, Berkeley Square, London, W.1 (Tel. : GROsvenor 6636).

The new offices will provide adequate accommodation for present and future work, and will serve as a far more accessible centre for those requiring information on zinc and its uses. Among the features of the building will be a permanent exhibition of zinc and zinc products.

Factors Influencing the Chilling of Cast Iron

By W. J. Williams, M.Sc., A.I.M. *

In addition to the effect of chemical composition, the chilling characteristics of cast iron are influenced by such factors as the nature of the charge, melting conditions, and melting and casting temperatures. In this brief account of work carried out in the B.C.I.R.A. laboratories on the effect of some of these factors, reference is made to the effect of inoculation and of the oxygen normally present in these low silicon irons.

THE graphitising or chilling characteristics of cast iron are governed by the composition of the metal, and also by physical factors which are not usually subjected to such close control. The influence of the principal elements, such as carbon. silicon, etc., on chill formation has been established, but the chilling potential of a melt cannot be assessed from a knowledge of the chemical composition alone. The nature of the charge, melting conditions, melting temperature and casting temperature, are known to influence the chilling characteristics. These factors are difficult to control, and it is for this reason that the chill test is still the final test applied to the metal in the chilled castings industry.

The chill test is only a guide, however, and the relationship between the depth of chill in the chill test and that in a larger casting sometimes fails. The depth of chill normally decreases as the depth of metal behind the chill increases, but there is no quantitative information available on this relationship. It is usual to adopt a chill test and then derive the relationship from experience.

A brief account is given, in what follows, of the effect of some of the principal physical factors on chill formation, using a chill test similar to those used in industry. This work was carried out at the laboratories of the British Cast Iron Research Association, and different aspects have been reported separately and in more detail elsewhere.[1, 2, 3] Reference will be made, where relevant, to the effect of inoculation on chill formation, and also to what is considered to be the effect of the oxygen normally present in these low silicon irons. Much of the experimental detail and reasoning upon which many of the statements and conclusions have been based, are omitted, in order to simplify the presentation and reference should be made to the above reports for further information.

Unless stated otherwise, the composition of the metal aimed at in each melt was as follows :—

T.C.	*Si*	*Mn*	*S*	*P*
3·2%	0·9%	0·35%	0·10%	<0·1%

The chill testpiece had the dimensions shown in Fig. 1 and was moulded vertically as shown in the elevation, care being taken to obtain a flat bottom face by moulding off a flat plate.

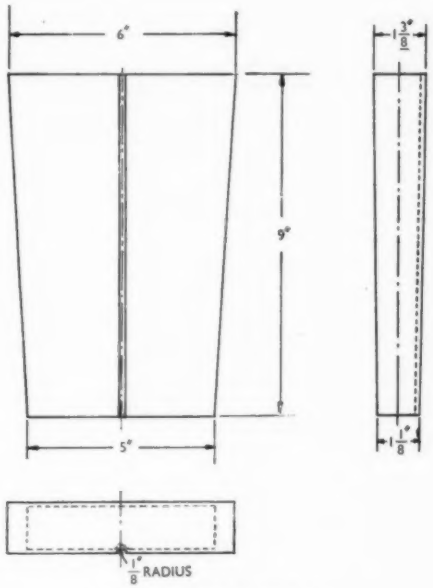


Fig. 1.—Chill test piece.

Effect of Melting Temperature on Chill Formation

The effect of melting temperature on graphite formation in grey irons has been known for some time. There is a refinement in graphite size with increasing melting temperature, and a corresponding tendency to chilling in thin sections. This observation led to two theories being put forward to explain the effect. The first, by Piwowarsky,[4] has become known as the graphite nuclei theory, and the second, proposed by von Keil and his co-workers,[5] as the silicate cloud theory. These theories also cover the graphitising effects of inoculation, particularly by ferro-silicon, and are given briefly because much of the work on the influence of superheating can only be explained by accepting some concept of nucleation.

The graphite nuclei theory postulates that the graphite flakes present in the charge do not dissolve completely when the metal is molten, but that submicroscopic particles of graphite, or small aggregates of carbon atoms grouped according to the crystal lattice of graphite, exist in the liquid, and that these centres nucleate the precipitation of graphite on subsequent cooling, thus having what may be termed a graphitising effect. It is assumed that super-heating progressively eliminates these nuclei.

The effect of inoculation by ferro-silicon is explained by assuming that when the addition is made there is a local concentration of silicon in the immediate vicinity

* Research Staff, British Cast Iron Research Association.

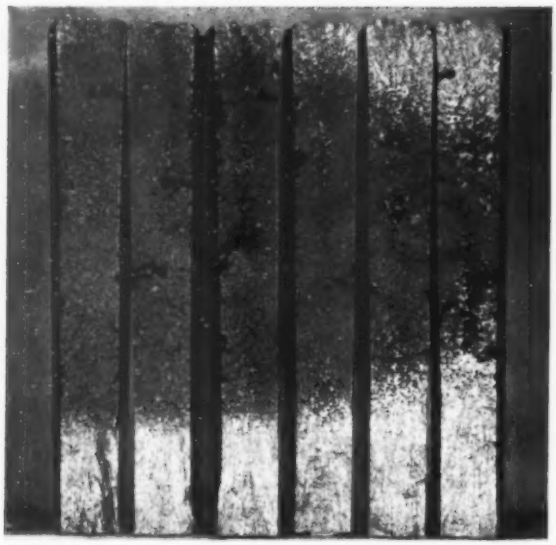


Fig. 2.—Chill tests showing the effect of melting temperature.*

of each particle added. The carbon equivalent in these zones exceeds 4·3%, resulting in the precipitation of small flakes of graphite (kish graphite) which have a nucleating effect. The elimination of the inoculating effect by holding the metal is assumed to be due to the gradual solution of these graphite particles.

The "silicate cloud" theory proposed by von Keil and his co-workers assumes the presence of a large number of submicroscopic refractory silicate particles in the metal which have an inoculating effect. Superheating causes these particles to melt, agglomerate, and float out of the metal, thus eliminating their inoculating potential. Inoculation with ferro-silicon is assumed to produce a fresh cloud of these submicroscopic refractory particles, and the gradual elimination of the inoculating effect with time on holding the metal is assumed to be due to the flotation of the particles from the melt.

The effect of melting temperature on chill formation is shown in Fig. 2. Reading from left to right, the melting temperature at which each test block was taken, was 1,350° C., 1,380° C., 1,410° C., 1,440° C., 1,470° C., and 1,500° C.: the casting temperature in each case was 1,320° C. There is a gradual increase in depth of chill as the melting temperature rises from 1,350° C. to 1,410° C., and this becomes more pronounced in the 1,410° C.–1,500° C. temperature range.

The effect of superheating is not eliminated by allowing the metal to cool in the furnace to a lower temperature and holding there for a period of time. The results of an experimental melt demonstrating this are shown in Fig. 3, where chill tests Nos. 1 and 2 show the depth of chill given by the metal on reaching a temperature of 1,350° C.; chill tests Nos. 3 and 4 show the depth of chill given on superheating to 1,500° C. and Nos. 5 and 6 show the depth of chill given by the metal after allowing the melt to cool to 1,350° C. and holding for 15 minutes at this temperature. The casting temperature in each case was 1,320° C. It will be shown later that the property destroyed by superheating can only be

* In all illustrations of this type, No. 1 test piece is on the left.

TABLE I

Chill Test No.	Melting Temperature	Graphite Addition	Carbon Pick-Up
1	1,390° C.	Untreated	—
2		0·2%	0·15%
3		0·6%	0·23%
4	1,500° C.	Untreated	—
5		0·2%	0·2%
6		0·6%	0·3%

regenerated either by casting the metal to give a grey base material and then remelting, or by inoculation with graphite.

The theories developed to explain the effect of superheating are extended in each case to cover the effect of inoculation, and the implication exists that inoculation with ferro-silicon may be considered as being the converse of the effect produced by superheating. Metal was inoculated with 0·5% of ferro-silicon (80%) after attaining temperatures of 1,350° C., 1,420° C., and 1,510° C., on heating, and the results are shown in Fig. 4. Chill tests Nos. 1, 3 and 5 show the effect of melting to 1,350° C., 1,420° C., and 1,510° C., and chill tests Nos. 2, 4 and 6 show the effect of inoculation with ferro-silicon at these temperatures. A comparison of chill tests Nos. 2, 4 and 6 shows that the effect of melting temperature persists even after inoculation. Inoculation with ferro-silicon results in a fixed reduction in the depth of chill in each case. The resulting depth of chill in the superheated metal is still greater than in the metal melted at lower temperatures.

A study of Fig. 2 indicates that superheating from 1,350° C. to 1,380° C. does not produce an appreciable increase in the depth of chill. If the state of inoculation of the metal at these low melting temperatures is due to residual graphite nuclei, then the introduction of more graphite nuclei should not be as effective as when introduced into metal which has been superheated. Metal was inoculated with blast furnace kish graphite on heating to 1,390° C. and 1,500° C., and the chill test fractures are shown in Fig. 5. The details are given in Table I.

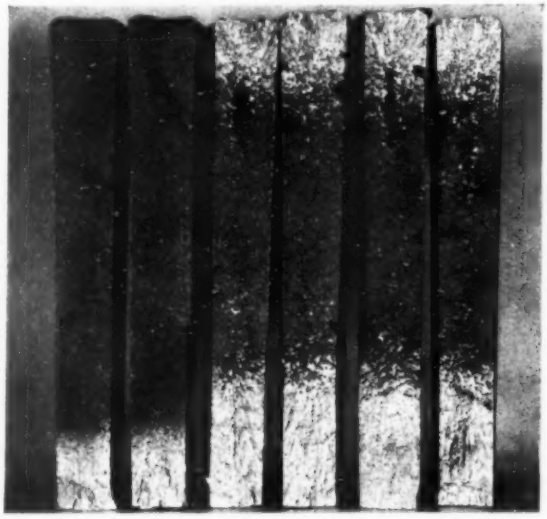


Fig. 3.—Chill tests showing the effect of superheating.

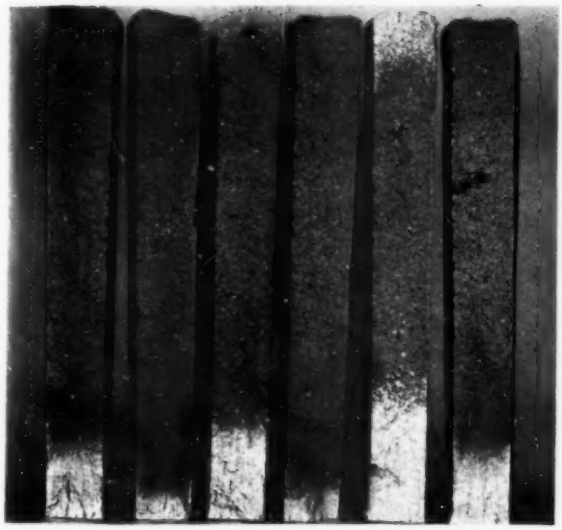


Fig. 4.—Chill tests showing the effect of inoculation with ferro-silicon at various temperatures.

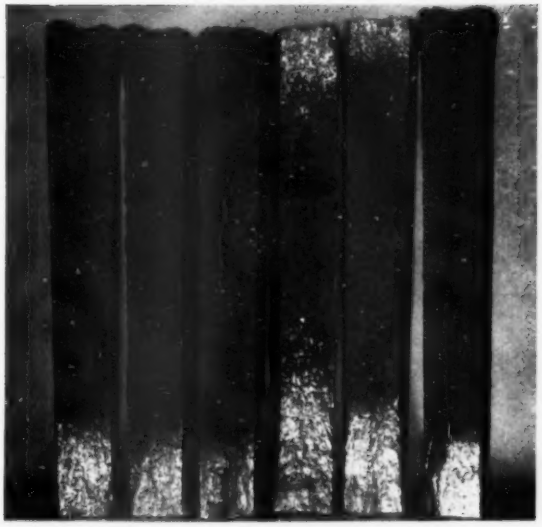


Fig. 5.—Chill tests showing the effect of inoculation with kish graphite at 1,390° C. and 1,500° C.

The graphitising effect of the additions is less marked in the colder metal than in the hotter metal, but of greater significance is the fact that the lowest chill level is the same in both the cold melted and superheated metal, i.e., the depth of chill is the same in No. 3 and No. 6.

Inoculation with graphite eliminates the effect of superheating, whereas inoculation with ferro-silicon does not.

Effect of Casting Temperature on Chill Formation

There is a decrease in depth of chill with decreasing casting temperature, and this is shown in Fig. 6 where chill tests 1 to 6 were cast at 1,420° C., 1,390° C., 1,360° C., 1,330° C., 1,300° C. and 1,270° C., respectively.

This effect of casting temperature is contrary to what would be anticipated from purely thermal considerations. The higher the temperature of the metal entering the mould, the greater the pre-heating of the chill plate and mould before the beginning of solidification: this preheating effect should reduce the depth of chill. The reduction in depth of chill with decreasing casting temperature found in practice would, therefore, appear to be due to chemical or physical changes within the liquid iron during cooling to the freezing temperature. One of the results of altering the casting temperature is that it alters the cooling rate of the liquid metal; for example, metal poured into the mould at 1,400° C. cools more rapidly to 1,300° C. than metal allowed to remain in the ladle until it reaches 1,300° C. before being cast. Based on this difference, the effect of cooling rate prior to casting was studied by fixing the casting temperature at 1,300° C. and altering the cooling rate of the metal in the ladle.

Two ladles, one of 120 lb. and one of 20 lb. capacity, were used. Both ladles were preheated sufficiently to eliminate moisture.

Approximately 90 lb. of metal was poured into the large ladle, allowed to cool to 1,300° C. and then cast. A further 90 lb. of metal was then tapped into this ladle, which had been considerably preheated by the previous metal, allowed to cool to 1,300° C. and then cast.

Approximately 20 lb. of metal was then tapped into the small ladle, allowed to cool to 1,300° C. and cast. A further 20 lb. of metal was tapped immediately into this ladle, and allowed to cool to 1,300° C. before casting the fourth chill test. The fractures are shown in Fig. 7, and the details are given in Table II. The difference in the rate of cooling in the large ladle does not affect the depth of chill, but rapid cooling in the small hand shank has a graphitising effect. This effect is converse to that anticipated.

Two further melts were prepared, one being inoculated

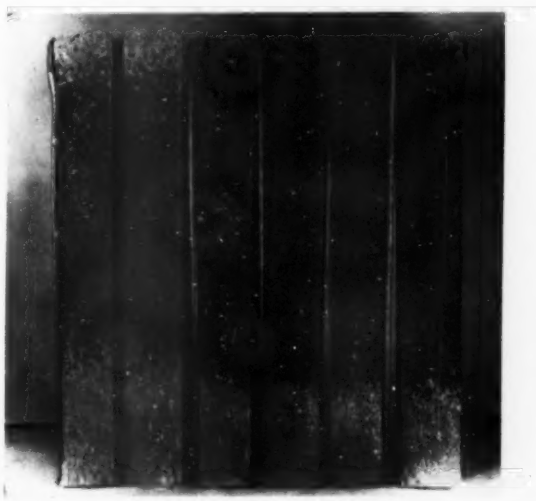


Fig. 6.—Chill tests showing the effect of casting temperature.

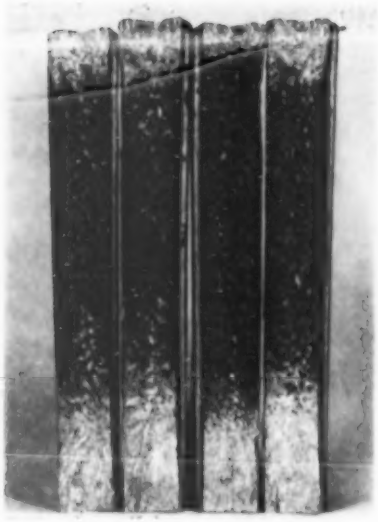


Fig. 7.—Chill tests showing the effect of cooling rate prior to casting.

with graphite ($\equiv 0{\cdot}2\%$ C) before tapping, and one with ferro-silicon ($\equiv 0{\cdot}2\%$ Si). It was thought that if the effects produced by changing the cooling rate of the metal were due to some form of nucleation, this effect would be pre-determined by the inoculating treatment, and the cooling rate down to the freezing temperature would have no further effect. The results, however, were again the same, that is, the two chill tests cast from the large ladle had the same depth of chill, and the first chill test cast from the small ladle (rapid cooling) showed less chill than the second chill test cast from the same ladle. It had been anticipated that the more rapidly cooled metal would give a deeper chill than the more slowly cooled metal, but each experiment showed the converse to be true when using the small hand

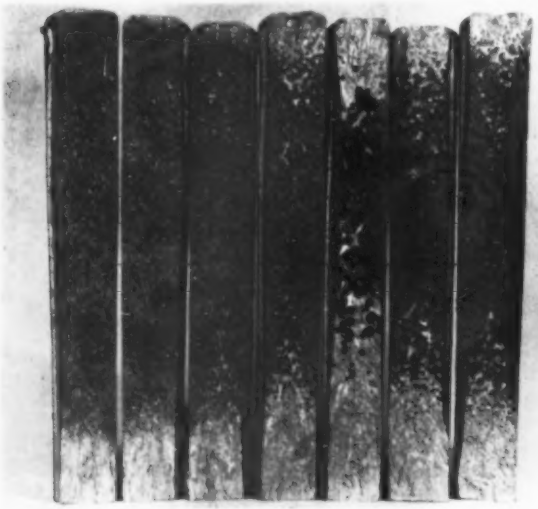


Fig. 8.—Chill tests showing the effect of varying melting and casting temperatures only.

TABLE II

Chill Test No.	Ladle	Cooling Time	Maximum Temperature in Ladle
1	Large	2 min. 18 sec.	1,360° C.
2		4 min.	1,400° C.
3	Small hand shank	1 min. 30 sec.	1,360° C.
4		2 min. 4 sec.	1,395° C.

shank. The different cooling rates in the large ladle did not influence the depth of chill.

Following the results obtained from these four melts, a further melt was made to determine the influence of casting temperature on chill formation, using the larger ladle containing 90 lb. of metal per tap instead of the small hand shank. The normal effect, i.e., a decrease in chill with decreasing casting temperature, was again found.

The range of chill depth which can be produced in metal from a single melt by altering the melting and casting temperature only is shown in Fig. 8. The details are given in Table III.

Influence of Melting Stock on Chill and Mottle Formation

Differences in the effects produced by the use of pig irons of apparently similar composition are frequently

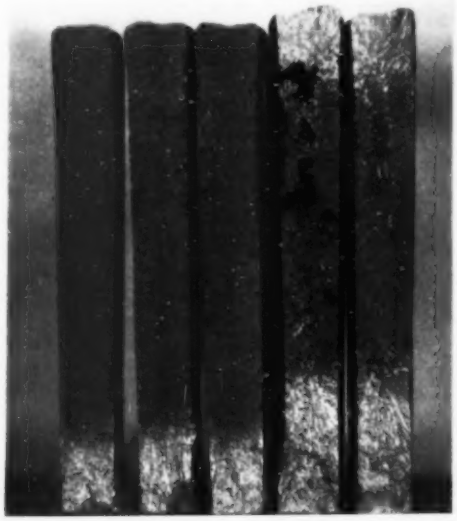


Fig. 9.—Chill tests showing the effect of superheating grey-base material.

reported in the literature, and the term "heredity" is used in this connection. The observed carbide stabilising effect of superheating, and the elimination of this by inoculation with graphite, would suggest that a grey-base material with the carbon present as graphite flakes would react differently from a white-base iron on remelting. This was shown to be the case by the following simple experiment.

A melt was prepared, heated to 1,350° C. and a chill test cast at 1,320° C. Half of the remaining metal was then cast in the form of 3 in. diameter bars in green sand moulds to give a grey-base material for remelting,

and the remaining half was cast into metal moulds to give a white-base material. The grey- and white-base materials were then remelted separately, and chill tests were cast from metal taken from each melt at melting temperatures of 1,350° C. and 1,500° C. The casting temperature was 1,320° C. in each case.

The chill given by the grey-base material on remelting is shown in Fig. 9, where chill test No. 1 shows the depth of chill obtained in the original base melt ; chill tests Nos. 2 and 3 show the depth of chill given by the grey-base material on heating to 1,350° C., and chill tests Nos. 4 and 5 show the depth of chill after superheating to 1,500° C.

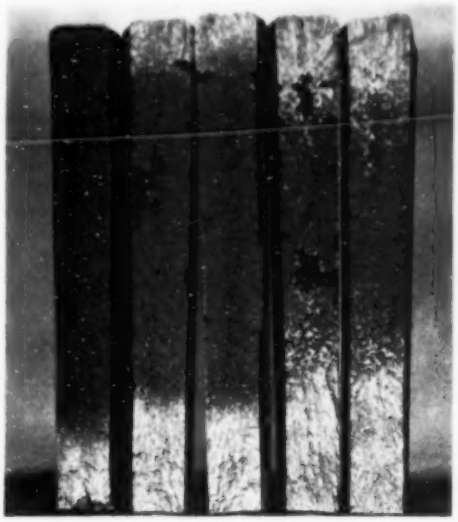


Fig. 10.—Chill tests showing the effect of superheating white-base material.

The depth of chill given by the white-base material on remelting is shown in Fig. 10, where No. 1 is again the chill test cast from the original melt ; chill tests Nos. 2 and 3 show the depth of chill on melting to 1,350° C., and chill tests Nos. 4 and 5 show the depth of chill obtained after superheating to 1,500° C.

The relative graphitising potentials of the white- and grey-base materials on melting to 1,350° C. and 1,500° C. is shown more clearly in Figs. 11 and 12, respectively. The relative effect on melting to 1,350° C. in each case is shown in Fig. 11, where chill tests Nos. 1 and 2 were taken from the white-base and chill tests Nos. 3 and 4 were taken from the grey-base. Similarly, the relative effect on melting to 1,500° C. is shown in Fig. 12 where chill tests Nos. 1 and 2 were taken from the white-base and chill tests Nos. 3 and 4 were taken from the grey-base material. It is clear that the grey-base material, although having the same composition as the white-base

TABLE III

Chill Test No.	Melting Temperature	Casting Temperature
1	1,340° C.	1,320° C.
2	1,410° C.	
3	1,440° C.	
4	1,520° C.	
5	1,520° C.	1,420° C.
6		1,350° C.
7		1,280° C.

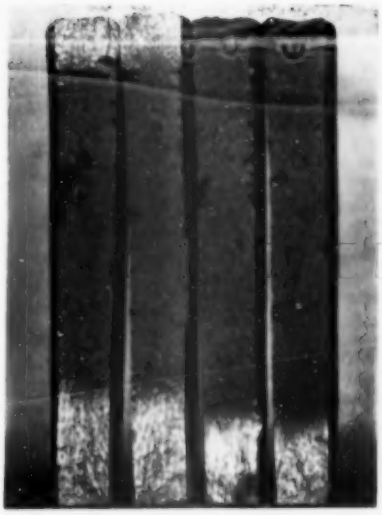


Fig. 11.—Chill tests showing the effect of white- and grey-base material on melting to 1,350° C.

material, has a greater graphitising potential at all melting temperatures. This effect is attributed to the graphite flakes present in the grey iron.

Effect of What is Considered to be Oxygen on Chill Formation

There has been considerable speculation on the effect of oxygen on chill formation, and the subject of "oxidised iron" has been discussed in a separate paper.[6] Analysis of some of the irons described above gave oxygen contents within the range 0·001% to 0·002%, and the results reported in what follows are assumed to be due to this oxygen, which is normally present in the iron.

There is evidence that the shape of the manganese

Fig. 12.—Chill tests showing the effect of white- and grey-base material on melting to 1,500° C.

Reduced ⅓ linear in reproduction

Fig. 13.—Large angular and also some elongated manganese sulphide inclusions in iron superheated to 1,350° C. Etched 4% picral. × 600

Reduced ⅓ linear in reproduction

Fig. 14.—Elongated type of manganese sulphide inclusions in iron superheated to 1,450° C. Etched 4% picral. × 600

sulphide inclusions in cast iron is related to the state of combination of the oxygen[3], and it is thought that the oxygen present in cast irons exists possibly as iron oxide or manganese oxide in the complex inclusions normally referred to as manganese sulphide.

A typical, large angular type of manganese sulphide inclusion found in iron which has not been superheated above 1,400° C. is shown in Fig. 13. This type is usually associated with the elongated or anchor type of manganese sulphide inclusion shown in Fig. 14, but disappears completely as the melting temperature rises above approximately 1,400° C., when all the manganese sulphide inclusions occur as the elongated type shown in Fig. 14.

Small additions of aluminium, or inoculation with ferro-silicon or calcium-silicide, just before casting, change the form of the inclusions to the type shown in Fig. 15 The inclusions are small, tend to be rounded in outline, and segregate in groups as seen in Fig. 15. Figs. 13, 14 and 15, taken at the same magnification, give an indication of the relative size of these inclusions. The cooling rate of the metal alters the size but not the type of the inclusions. The small compact type shown in Fig. 15, and produced by inoculation, will revert to the elongated type on holding the metal.

The effects of oxidising conditions on superheated metal have been studied by American investigators[7], who conclude that the carbide stabilising effect of superheating is due mainly to an increase in the oxygen content of the iron. The following work, however shows that the effects of superheating are not entirely due to oxygen, and the evidence suggests that the oxygen normally present in cast iron has a graphitising effect.

Working on the assumption that the addition of aluminium to cast iron results in the formation of some Al_2O_3, then it requires approximately the same percentage of aluminium to neutralise the oxygen present. The effect of small additions of aluminium to an iron superheated to 1,500° C. is shown in Fig. 16, and the details are given in Table IV.

The aluminium content throughout was less than 0·01% as determined by spectrographic analysis. The change in the form of the manganese sulphide inclusions indicates that sufficient aluminium dissolved in the metal to give the effects associated with deoxidation. The surprising observation, however, is the slight carbide stabilising effect which has been produced by the small aluminium additions. This is almost certainly due to the indirect effect of aluminium on the oxygen present and, if this assumption is correct, then the oxygen normally present in cast iron has a slight graphitising effect when powerful deoxidising elements are absent.

It has already been shown[3] that aluminium and ferro-silicon additions to cast iron modify the form of the manganese sulphide inclusions in a similar way. The effect of small additions of 80% ferro-silicon on chill formation is shown in Fig. 17 and the details are given in Table V.

Similar results were obtained by additions of calcium-silicide and it is assumed that this effect is due to the presence of aluminium in the ferro-silicon, and to the

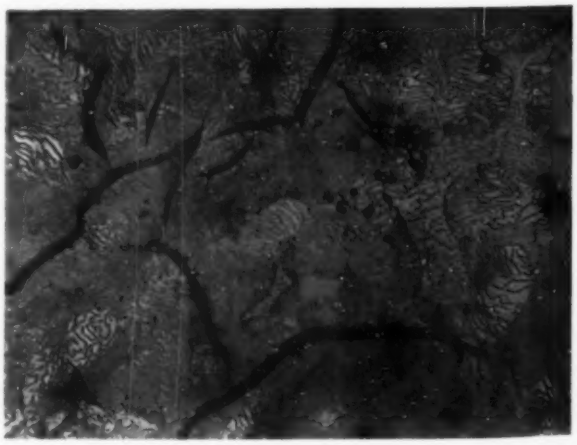


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Fig. 15.—Compact type of manganese sulphide inclusions produced by inoculation. Etched 4% picral. × 600

TABLE IV

Chill Test No.	Treatment	Form of the Manganese-Sulphide Inclusions
1	Untreated	Elongated or anchor type
2	0·4 g. Al ≡ approx. 0·004%	Small round inclusions + some elongated
3	0·6 g. Al ≡ approx. 0·006%	Small round inclusions
4	0·8 g. Al ≡ approx. 0·008%	Small round inclusions
5	1·0 g. Al ≡ approx. 0·01%	Small round inclusions
6	1·2 g. Al ≡ approx. 0·012%	Small round inclusions

deoxidising effect of the calcium in the case of the calcium-silicide addition.

Larger additions of aluminium, ferro-silicon and calcium silicide reduce the depth of chill.

Summary

The salient features may be summarised as follows :—

(1) Super-heating increases the depth of chill. This increase becomes more pronounced as the temperature exceeds 1,400° C.

(2) Inoculation with ferro-silicon does not eliminate the effect of super-heating. It removes a fixed amount of chill in both cold melted and superheated metal.

(3) Inoculation with graphite eliminates the effect of superheating, resulting in the same depth of chill in cold melted and superheated metal. Inoculation with graphite is, therefore, more effective in superheated than in cold melted iron.

(4) The graphitising effect associated with cold melted iron does not return by holding the metal at a low temperature after it has been superheated.

(5) The original graphitising potential can only be regenerated either by inoculation with graphite, or by casting the metal to give a grey-base material and then remelting.

(6) There is a progressive decrease in depth of chill with decreasing casting temperature when the iron contains normal amounts of manganese and sulphur. The effect of casting temperature on chill formation is erratic when the manganese and sulphur contents are low.

(7) Rapid cooling in the ladle to the casting temperature appears to decrease the depth of chill, but this effect was only detected with small amounts of metal cooled rapidly in a hand shank.

(8) A grey-base material gives less chill at all stages of melting than a white-base material produced from the same original melt, and thus having the same history and composition.

(9) There is a relationship between the form of the manganese sulphide inclusions and the melting temperature. The manganese sulphide inclusions are also modified by the addition of elements which have an affinity for oxygen, and by melting in vacuum.

(10) Small additions of aluminium, ferro-silicon and calcium silicide have a slight but positive carbide stabilising effect before the graphitising effect normally associated with these additions becomes apparent.

These results can only be interpreted by assuming that the oxygen known to be present in the iron under normal melting conditions has a graphitising effect.

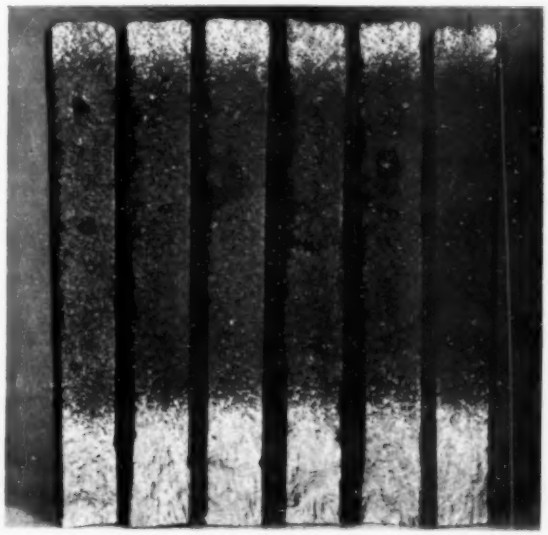

Fig. 16.—Chill tests showing the effect of small additions of aluminium to iron superheated to 1,500° C.

TABLE V

Chill Test No.	Treatment
1	Untreated
2	1 g. Fe-Si (80%) ≡ approx. 0·008% Si
3	2 g. Fe-Si (80%) ≡ approx. 0·016% Si
4	3 g. Fe-Si (80%) ≡ approx. 0·024% Si
5	4 g. Fe-Si (80%) ≡ approx. 0·032% Si
6	5 g. Fe-Si (80%) ≡ approx. 0·04% Si

Fig. 17.—Chill tests showing the effect of small additions of 80% ferro-silicon.

Acknowledgment

The author wishes to express his thanks to the Council and Director of the British Cast Iron Research Association for permission to publish this paper.

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Steel Technology and Market Development

E.C.E. Report on Recent Advances

WITH a view to making available to people interested in steel from the commercial and essentially lay angle a straightforward account of some of the more promising developments—many of them discussed in their broad economic setting—the Secretariat of the United Nations Economic Commission for Europe has recently published a report entitled "Recent Advances in Steel Technology and Market Development, 1954". The report has been compiled on the basis of contributions made by experts in the respective fields, the items being selected for their potential value in increasing productivity and improving efficency, thereby reducing costs.

In a special introduction to the report, Sir Charles Goodeve, Director of the British Iron and Steel Research Association, sets out his idea of what the rapidly developing steel industry may look like in Western Europe ten years from now. The aims of Western European countries to raise steel output suggest that total production in 1965 may be in the neighbourhood of 90 million metric tons, as compared with 68 million metric tons last year. Sir Charles concludes: "We can look ten years forward with confidence to a healthy steel industry which, in its products and its processes, matches up to the striking technical advances which are taking place in this age of nuclear energy."

The report, the third in the series of annual papers, is divided into four sections which deal respectively with: ore preparation, coke production and blast-furnace practice; steel making developments; rolling and finishing; and recent progress in the technique of market development. This last section represents a new element in the publication: in it are analysed the organisational structure and work being done in steel market development in a number of countries, and certain comments and suggestions for expanding the market for steel are made.

Ore Preparation, Coke Production and Blast Furnace Practice

The first feature dealt with in this section of the report is iron ore preparation. Attention is drawn to the reversal of the earlier theory that lump ore is desirable and fines undesirable. Consideration is now being given in some quarters to the use of the complete preparation (crushing and sintering) of the iron ore burden. The report's introduction signals the considerable technical advances which have been made in the preparation of sinter, with a resultant improvement in both quality and cost. The use of sinter is advancing rapidly, particularly in the United Kingdom, where the figure of 3·5 million tons in 1939 has risen to 9·5 million tons in 1954.

Sir Charles Goodeve also draws attention to the increasing demand for iron ores, and reference is made to the revolutionary methods now in use which result in very high labour productivity in Sweden In spite of this, much will have to be imported from West and North Africa and Labrador, where further large deposits are now being opened up. Developments in the Lorraine ore fields are of particular interest, because this basin is one of the largest in the world. It produced 39·5 million tons of iron ore in 1953, but by modernisation was able to increase this figure to 41·2 million tons in 1954.

The steady growth of steel production raises many raw material problems. The new methods of coking developed in the Lorraine coal fields are, therefore, dealt with in the report. The Lorraine coal basin in France has large coal reserves, but of a quality which hitherto has been regarded as unsuitable for the production of metallurgical coke. By careful blending and paying particular attention to the chemical, physical and mechanical properties of the coal, it has been possible to produce a satisfactory coke in increasing quantities. The use of Lorraine coal has increased from 490,000 tons in 1950 to 1,230,000 tons in 1954, with a forecast increase to 2·6 million tons in 1956. This rapid rise suggests that a big step has been taken towards solving the problem of producing metallurgical coke from at least one large field which has hitherto been regarded as unsuitable. The solution found in the Lorraine basin might, with suitable adaptation, be applicable to other areas where the main deterrent to large-scale pig iron production is the lack of conventional coking qualities of coal.

Interesting experiments have recently taken place in the production of ferro-coke, a coke rich in iron and with high resistance to crushing which is formed by carbonizing gas coal mixed with a fine grade of suitable iron ore in conventional coking ovens. Experiments have taken place in Western Germany using a steadily increasing proportion of ferro-coke and a correspondingly decreasing proportion of ordinary coke. Although the results proved interesting, the trials were on a comparatively small scale, and it still remains to be seen whether ferro-coke can be efficiently used in large modern blast furnaces.

The possibility of pre-refining pig iron outside the blast furnace is of value and reference is made in the report to desulphurising, along lines developed in Sweden, by the addition of lime in a rotary kiln, and to methods of desiliconisation adopted in the United Kingdom by the use of graded limestone and a little fluorspar.

The future of the blast furnace has always been a matter of controversy, but the belief is expressed by Sir Charles Goodeve that in ten years' time the blast furnace will still be with us, because of its high thermal efficiency, whereby it uses 95% of its heat usefully, and because of its high labour productivity. On the other hand, an

account is given of the development of special types of blast furnaces, the particular interest lying in the fact that lower grade materials can be used in such furnaces.

A brief account is given of recent developments in the low shaft furnace, which was dealt with in more detail in the 1953 E.C.E. Steel Technological Review. The principal object of the low shaft furnace is to find a means of producing pig iron from coal of essentially non-coking quality and from fine ores. It appears that the problem of preparing the furnace charge has been solved in small-scale production, but it has yet to be shown whether it would in fact be economic on a large scale.

There follows a discussion of the Lubatti furnace, developed in Italy, in which pig iron is produced from pyrites and various iron-rich dusty residues. The principle is that the furnace charge is fed continuously on to the surface of liquid slag, and the advantages claimed are that low-carbon iron can be produced from poor materials ; the thermal efficiency is good ; and the capital and operating costs are low. The only major difficulty so far is the problem of the furnace lining, which has not been entirely solved. It would appear that the furnace would be suitable for the production of pig iron from various iron bearing residues, particularly in countries which have as yet no large scale pig iron production, although cheap power would appear to be an essential pre-requisite.

Steel-Making Developments

In the introduction to the report attention is drawn to the rapid technical progress made in the use of blowing with oxygen or oxygenated gases to reduce the nitrogen content of converter steel, and to lower the melting time in both converter and open hearth furnaces. Reference is also made to the possible increased usage of the side-blown basic converter and the increased extent of electric steel-making. In the future, steel may be made to some extent with electricity generated from nuclear energy—in the United Kingdom within the next ten years.

The report, based substantially on papers produced by experts from the United States, the United Kingdom and Austria, draws attention to the efforts made to increase productivity and so to reduce the cost of commercial grades of steel. Four particular features of technical progress are referred to ; they are :—

(1) Bottom-blown basic converters using various combinations of enriched blast.
(2) Top-blown converters relying solely on oxygen blast.
(3) Basic open hearth furnaces of steadily increasing size and embodying numerous detailed improvements, including the use of oxygen to speed up scrap melting and decarburisation.
(4) The duplexing process which, in principle, consists of using blown metal at an intermediate stage between blast furnace hot metal and finishing in an open-hearth furnace.

Commenting on the fact that the outstanding difference between Europe and the United States is the higher rate of productivity achieved in the United States, the report suggests that the main reasons for this are : excellent organisation of the flow of materials ; reduced repair times ; larger furnaces ; and better raw materials. The larger furnaces are mainly the outcome of the rationalisation of American steel production, made possible by the existence of a huge single market.

The conclusion is drawn that productivity could be greatly increased by means such as improvements in furnace design ; increased use of oil under certain conditions ; improved charging facilities together with improved arrangements for handling the steel after tapping ; greater speed of repairs ; better instrument control ; increased proportion of pig iron ; the adoption of the continuous working week ; and the use of improved furnace linings.

In open hearth furnaces improved production and shorter tapping times can be obtained not only by improvements of the nature mentioned above but also by the partial pre-blowing of hot metal in converters, with finishing in open hearth furnaces, a process known as duplexing. The suggestion is made that in existing works having say, six to eight open hearth furnaces, two or three of the older type furnaces might be replaced by either conventional or oxygen-blown converters. The productivity of these furnaces would be improved if one or other of the various methods of using oxygen or oxygenated gases were adopted. In this connection the availability of mass produced oxygen at reasonable cost is essential, a problem which was discussed more fully in last year's review.

In a discussion of the problems of the future, reference is made in the introduction to the important developments in Western Germany in the vacuum methods of removing hydrogen and other dissolved gases from high-grade alloy steels.

Rolling and Finishing

Many detailed developments in rolling and finishing have taken place recently, but the present paper deals in detail with two subjects only. The first covers electronic control of gauge and tension in the rolling of flat products, and the second continuous casting. A brief note is added on the economics of the steel extrusion process developed in France, and some mention is made of the production of tubes by the stretch reducing process, developed particularly in Western Germany.

The introduction refers to the importance of installing apparatus which enables an operator to set up in advance a whole sequence of roll positions and so speed up the throughput of the mill. It foresees that a large proportion of the more expensive steels will be produced by continuous casting in the future, thus eliminating the ingot stage and the primary mill. By integrating continuous casting with rolling, and by sending billets straight from the continuous casting machine to the rolling mill, reheating furnaces as well as soaking pits will also be eliminated, and a great saving in fuel and plant achieved. Now that the practical difficulties of continuous casting have been overcome, it is likely that, in conjunction with continuous casting, extrusion will find increasing application to steel during the next decade.

Recent Progress in the State of Market Development for Steel

To be effective, technical progress has to be applied fully in practice, and this involves active efforts to expand the market itself. In a comparison of market development in individual European countries and in the United States, the report shows that market development is in many ways less highly developed in Europe than in America. At the same time, the analysis shows by examples that much has been done recently in a

number of European countries to promote both the development of markets for steel and the better use of steel. Much more could be done, however, particularly in the following directions :—

(1) The provision of greater resources for the conduct of effective market development in its many aspects, particularly at the company level.

(2) The establishment of closer working relations, particularly at the technical level, between engineers from the steel industry and the steel-consuming industries, to devise new and more economical ways of using steel, adjusting steel specifications, changing, where appropriate, designs in the consuming industry, or devising improved methods of production in the consuming industry.

(3) Detailed field enquiries on the relative merits of steel and other materials in specific applications, together with a wide dissemination of results achieved.

(4) Wider application of standardisation, both on national and international levels. Since a modern iron and steel plant can produce a wide range of products, there is a general tendency for each country to try to meet the whole range of requirements. There would appear, however, to be more scope for co-ordination of production programmes between producers in the same geographical area and thus greater specialisation in the range of products manufactured. This, in turn, would tend to avoid over-proliferation of sizes and specifications.

(5) An adjustment of price structures, so as to provide adequate and proper incentives for the greater use of steel, particularly in new forms or in new ways.

Aero Research Coming-of-Age

H.R.H. The Duke of Edinburgh visits Duxford

A SPECIAL display commemorating the 21st anniversary of Aero Research Ltd., Duxford, Cambridge was visited by H.R.H. The Duke of Edinburgh on 20th April. The Duke flew by a helicopter of the Royal Navy from London and was greeted on arrival by Mr. Raymond Needham, Q.C., Chairman of the Company, with Dr. N. A. de Bruyne, Managing Director and Mr. R. F. G. Lea, Commercial Director.

Aero Research, Ltd., are best known today for their synthetic resin products, mostly employed in the role of adhesives as, for example, Redux, for bonding metal aircraft structures ; Aerolite urea-formaldehyde glues for wood ; and Araldate epoxy resins for electrical components. But the theme of the display might have been termed " bridging the gap between science and industry." for it comprised the results of twenty-one years of research, including the development of new materials, and concluded with examples of products of the many industries in which synthetic resins are now employed.

The Company was formed in 1934, mainly to investigate new material for aircraft structures, and part of the display featured such materials as Gordon Aerolite (which has *still* a greater strength/weight ratio than any other known material) and metal honeycomb for making sandwich structures—a material in which aircraft designers are showing increasing interest. A series of demonstration units showed how strains occur in glued joints, how wetting is essential to good adhesion, and how radio frequency and strip heating can be applied to accelerate the setting of synthetic resin glues. A Tormentor Yacht station " Flying Fifteen " glued throughout with Aerolite 300, an aircraft spinner of Araldite epoxy resin and glass cloth, in addition to a number of Redux-bonded aircraft components, were among the examples of products made with synthetic resins. Briefly, the display was designed to show the results of investigations into adhesives and adhesion, the development of new materials, and the applications of these products in modern industry.

In the course of his visit, the Duke witnessed the lifting of an Aston-Martin car (weighing 30 cwt. in its cradle) suspended from a 3¼ sq. in. Redux-bonded metal-to-metal joint. A joint of these dimensions allowed considerable safety margin and could, in fact, have supported the weight of three such cars. His tour of the works included the Aerolite urea-formaldehyde glue factory, the Research Laboratories and the Redux Department, where honeycomb floor panels for the Fokker Friendship airliner and components for the Fairey Rotodyne and the Bristol Britannia were being bonded.

Courtesy of Cambridge Daily News.

His Royal Highness inspects parts made with epoxy resin

His Royal Highness was presented with polo sticks made with Araldite epoxy resins, while on behalf of Prince Charles and Princess Anne he accepted a radio-controlled model motor cruiser and a scale model of his yacht Cowslip, both glued with Aerolite.

THE English Electric Co., Ltd., has opened a new Sub-Office at Barclays Bank Chambers, 3, Trinity House Lane, Hull, (Telephone No. 35533) to cover an area that corresponds to No. 6 Sub-Area of the Yorkshire Electricity Board.

Some Recent Furnace Installations

Applications in the Fabrication and Heat Treatment of Metals

Courtesy of Birlec, Ltd.

Standard furnace suitable for a variety of applications.

The selection of suitable heat treatment equipment is usually a compromise between the ideal and the practical : as many variables are involved which affect the quality and overall cost of heat treated products, great care must be taken in estimating requirements and in designing the furnace to meet them. In this review it is possible only to indicate the trend of development in furnace design by showing and describing briefly a few of the more recent installations and the purposes for which they are being applied.

IN its widest sense, heat treatment embraces all processes involving heat, by which the physical and mechanical properties of metals and alloys are affected. In that sense it can be said to be associated with all the processes used in converting ores into finished metal products. In a narrower sense, however, heat treatment is an operation, or combination of operations, involving the heating and cooling of a solid metal part for the purpose of obtaining certain desirable properties. Basically, it involves no chemical change, the transformations occurring in the material including phase changes, the passage of compounds into or out of solid solution, and the expansion and contraction of solid parts. Thus, except in such processes as the carburising and nitriding of steel, there is no change in the average composition of the material.

The initial and final operations in any heat treatment cycle involve heating of the cold metal and its subsequent cooling to atmospheric temperature. An important factor in the successful operation of any cycle is the rate at which heat may safely be put into or removed from the material. Rates of heating and cooling may vary widely, from very low to very high, such as is the case, for example, when a cold part is dropped into a lead or salt bath, or when hot parts are plunged into a quenching tank. Large parts of soft steel, or small parts of hard steel, can easily be ruptured by heating too rapidly ; even if the part does not crack, uneven heating or cooling may distort it. Thus, the heating rate must be adjusted to the size of the material or component, its condition during heating, and the eventual temperature required. Heating high speed steel to the very high quenching temperature necessary, for instance, must be carried out in two or three stages ; a preheating furnace is usually provided, and some cautious and successful operators use a low drawing furnace for a preliminary warm up. It will be realised that charging a cold load into a hot batch furnace will give the material—and the furnace—quite a thermal shock. The cooling rate is not less important, and in this case the properties of the material may be governed largely by the rate.

While the process of heat treatment, in the above sense, is applied with a view to modifying the constitution and structure of the metal, by controlling the heating and cooling conditions under which changes in the solid state occur, all the desired properties may not be improved by a particular procedure ; it is generally necessary, therefore, to develop the most desirable combination of properties in the material for a specific purpose.

Considerable attention is also being given to-day to the heating of ferrous and non-ferrous materials for their preliminary forming operations, because of its influence on the final structure, as well as on manipulation, and greater care is being taken in controlling temperatures and in protecting the material.

Satisfactory results in the achievement of these objectives depend largely on the design of the furnace for the work involved, on its equipment, on the material to be treated, and on the furnace operator. It should be remembered that the first function of a heat treatment furnace, whether the heating medium be solid fuel, gas or oil fuel, or electricity, is to give a satisfactory product at the lowest cost consistent with uniformity of heating. When making a choice of equipment, it is important to bear in mind this need for producing a high grade product at low cost, using that form of heating medium and type of equipment which will give these results under the conditions prevailing in the works concerned.

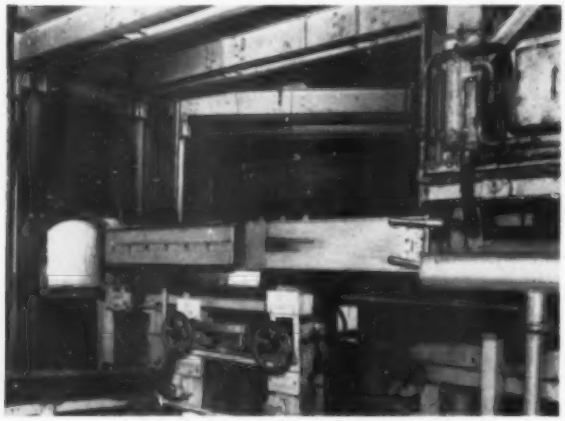
Courtesy of Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 1.—Rotary hearth furnace for Pilger mill.

It should also be remembered that the output of a furnace, allowing a reasonable margin for overload, is decided at the design stage, and cannot readily be increased beyond this capacity without risk of unsatisfactory treatment.

In those industries where mass production predominates, the duty demanded of heat treatment furnaces may amount to a precise and clearly defined treatment and output. To meet this requirement, furnaces are so designed, and operate with such precision, that they can be located in the production line. In such cases the allowable margin to cover contingencies and unknown factors is greatly reduced, but a fair measure of flexibility of output and range of temperature is needed in many types of heat treatment plant for general purpose use.

Almost invariably heat treatment processes are carried out in batch, continuous, or semi-continuous furnaces; the exception being when induction heating is employed, with special arrangements for the treatment of particular products. The most widely used furnace is, undoubtedly, the batch type. Its adaptability for handling materials varying considerably in size and quantity, and even in the type of treatment required, has made it an essential piece of equipment in practically every field where metal has to be processed. Unfortunately, this very wide field of application has compelled furnace manufacturers, in catering for individual users' requirements, to produce a host of special-purpose designs which, in the main, have conflicted with the development of really standardised types.



Courtesy of Salem Engineering Co., Ltd.

Fig. 2.—A magnetic charging machine by which more than one billet can be charged at a time.

Long and varied experience of many users' requirements, however, has made it possible for some manufacturers to evolve certain types of equipment conforming to a basic design, which can be repeated for a wide variety of applications. A typical example is that of a basic design developed for annealing, normalising, hardening, tempering, nitriding, pack carburising and other processes involving temperatures up to 1,050° C. Another, of similar design, incorporates a special system of atmosphere control for the clean hardening of such components as tools, dies, gauges and other products for which a scale-free finish is essential. Recently, a new standard type of equipment has been produced combining these two features. At present, two models are available, rated at 20 and 30 kW., respectively, but it is expected that these will be supplemented by further additions to the range. This is known as the RS type and has been developed by Birlec, Ltd. One of the models is illustrated at the head of this review.

When the output of a product requiring the same heat treatment is fairly constant, there is an opportunity for using a type of furnace in which the product to be treated can be handled automatically, and in which heating and cooling are continuous operations. Between batch and continuous furnaces are various designs which can be regarded as being of a semi-continuous character. In addition to temperature control, and in some cases atmosphere control, certain furnaces have time cycle control, and are designed to repeat accurately a desired treatment, with a view to obtaining products of uniform quality. Furthermore, continuous furnaces can have their temperature zones adjusted for better treatment of both work and furnace; this is especially important when the parts to be treated have large differences in cross section.

With induction heating, there is, in many cases, no furnace in the accepted sense, but this technique is used to carry out metallurgical operations that would normally be done in a conventional furnace and, since it is being increasingly applied, particularly in mass production, references to its application will be made in this review.

Reheating Furnaces

An interesting trend in recent years has been the changeover from the roll-down or pusher furnace to the rotary hearth furnace for heating billets in the tube industry, and several large installations have been put into operation during the past year. The main advantages of the rotary hearth furnace are the spaced heating and the elimination of scale disturbance, since the billets to be heated, whether round or square, are so placed in the furnace that they do not touch each other. The all-round heating resulting from the spacing out of the billets is particularly important in tube manufacture, as troubles at the piercer are inevitable if the temperature gradient from centre to surface is not concentrically even.

A large rotary hearth furnace, complete with mechani-

cal handling equipment, has recently been designed and constructed by The Wellman Smith Owen Engineering Corporation, Ltd., for Messrs. T. I. (Group Services), Ltd., at The Weldless Steel Tube Works, Wednesbury, which will handle billets from 6 to 15 in. diameter and 2 ft. to 6 ft. 11 in. long. It has a mean effective hearth diameter of 35 ft. with a hearth width of 11 ft. 3 in. The nominal output of this furnace is 11 tons/hour, with a possible maximum of 17 tons/hour, when heating billets from cold to 1,250° C.

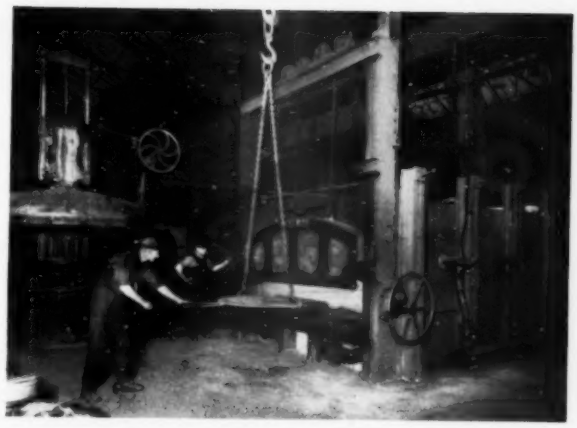
In this furnace, shown in Fig. 1, the billets are manipulated on the hearth by Wellman charging and discharging machines, and may be located in position according to length. The charging and discharging doors are set at an angle of 35° to each other, to permit the charging and discharging machines to operate properly. Across the furnace, in the space between the doors, an air-cooled curtain wall is suspended. The furnace is fired with clean producer gas through Basequip K burners, using air preheated to approximately 300° C. The burners are grouped together to form four zones in the furnace, namely, a preheating zone, two heating zones, and a soaking zone. Both the heating zones and the soaking zone may be operated by automatic control, but the preheating zone is arranged for manual control only, except that in this zone also an automatic fuel/air ratio controller is in operation. Hand-operated gas and air valves in the zone mains enable any zone to be isolated if required.

This application of rotary furnaces to the heating of billets for tubes emphasised the need for automatic charging and discharging, with machines interlocked with definite movements of the hearth. Two large units in Italy and one smaller unit in Sweden, by Salem Engineering Co., Ltd., are now in operation with both charging and discharging machines fully automatic, and only remote control at the piercer for stopping and starting the automatic sequence. The machines are basically hydraulic in operation, using a hydraulic unit both as a motor and a brake. The billet is actually placed on the hearth, not dropped, and during discharging is lifted clean from the hearth before being moved out of the furnace, thus obviating any drag on the hearth.

As a further development in this connection, Salem Engineering, in conjunction with G.E.C., have developed a magnet type charging machine. This magnet charger has two main advantages, in that billets can be charged with their ends touching, or with very little gap between them, and, as more than one billet can be picked up at a time, the number of charging operations is reduced, with a corresponding reduction in heat losses through the charging door.

The main problem was the design and construction of magnets to replace mechanical grips so that they could be inserted into a furnace operating at a temperature of 1,000–1,100° C. without detriment to the magnets. This has been achieved by a system of water jackets along both sides of the magnet and extension arm, water being circulated independently on each side of the magnet. Fig. 2 shows a magnet charger for a rotary hearth furnace built by Salem for one of the leading tube producing firms.

Accurate heat distribution and temperature control in heating furnaces is just as important for stamping, forging or pressing, and a typical example of a plate furnace for the fabrication of boiler ends is shown in



Courtesy of Wellman Smith Owen Engineering Corporation, Ltd.

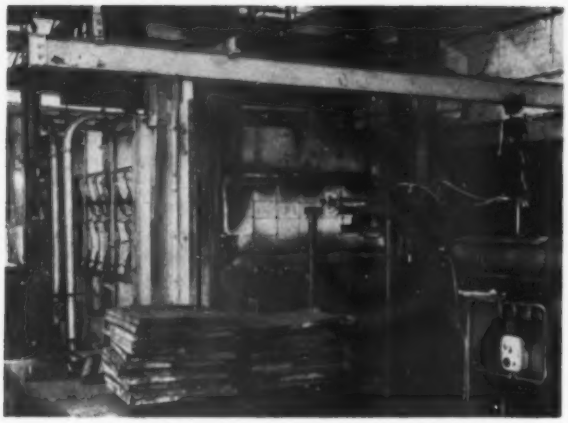
Fig. 3.—Solid hearth in-and-out type of furnace for boiler plate heating.

Fig. 3. This is a solid hearth furnace designed and constructed by The Wellman Smith Owen Engineering Corporation, Ltd., having internal dimensions 10 ft. long by 8 ft. wide by 3 ft. high ; it is designed to heat plates up to 1¼ in. thick from cold to 1,200° C. The average output of the furnace when heating 7 ft. diameter plates 1¼ in. thick is 1 ton/hour.

Heating of this furnace is effected by means of four low-air-pressure type oil burners, two being situated in each side wall and arranged to give even heating over the complete hearth. Consumption of heavy fuel oil is approximately 20 gal./hour, when supplied to the burners at a pressure of 15 lb./sq. in. and at a temperature not exceeding 200° F. Air is supplied by a centrifugal fan giving a pressure at the burners of 20 in. w.g. Exhaust ports are spaced evenly across the width of the furnace hearth near the door, and the exhaust flues run the length of the furnace underneath the hearth. Combustion air is preheated to a temperature between 150° and 200° C. by means of air preheater tubes located in the exhaust flues ; these tubes are arranged for easy

Courtesy of G.W.B. Furnaces, Ltd.

Fig. 4.—An aluminium billet heating furnace with automatic mechanism for discharging two billets at a time for cable sheathing.



Courtesy of Incandescent Heat Co., Ltd.

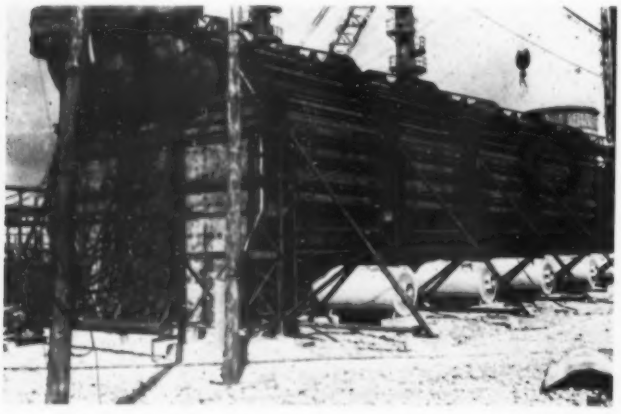
Fig. 5.—Balanced hearth walking beam furnace installed at The Mint (Birmingham), Ltd., for heating copper slabs and billets.

inspection or renewal without disturbing the main furnace brickwork.

In an earlier issue there was a description of an aluminium billet heating furnace which has recently been installed in the Prescot Works of British Insulated Callender's Cables, Ltd., for cable sheathing, but it seems appropriate that brief reference to this interesting installation should be made in this review. The furnace selected was an electrically heated unit designed by G.W.B. Furnaces, Ltd. It was required to work in conjunction with a Loewy press and involved heating billets to the right temperature for extrusion into tube. The billet temperature required for sheathing directly on to some types of cable core is of the order of 300° C. or less, but the equipment may also be operated up to 450° C. for other production purposes. The furnace has an internal chamber 20 ft. long by 1 ft. 3 in. high, and six rows of diabolo-shaped idler rollers are fitted in the hearth. The size of the aluminium billets in the charge varies from 6¼ in. diameter by 12 in. long up to 9 in. diameter by 18 in. long, and the maximum output for which the unit has been designed is 1,680 lb./hour at 450° C. The total rating of 165 kW. is divided into two automatically controlled 10 ft. long zones, and spread evenly over the 3-phase mains supply. The first zone, where the initial heating of the billets takes place is rated at 105 kW. The automatic discharge mechanism of the furnace is arranged to provide two billets at a time at the correct extrusion temperature; the discharging end of the furnace is shown in Fig. 4.

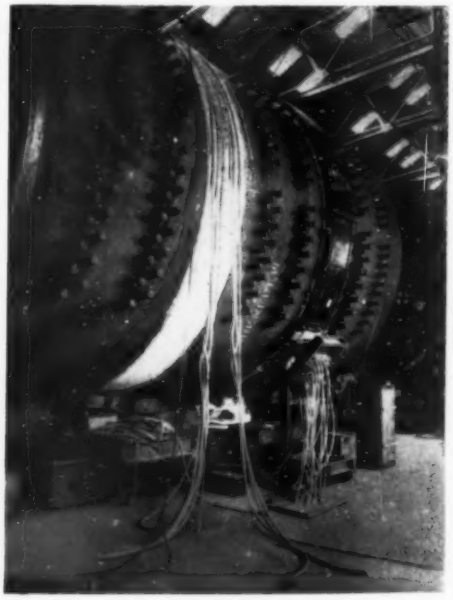
A balanced hearth walking beam furnace, fired by town's gas, is shown in Fig. 5. Designed and constructed by Incandescent Heat Co., Ltd., for The Mint (Birmingham) Ltd., it is used for heating copper slabs up to 4 in. thick and weighing 330 lb. each, and also for round billets up to 4 in. diameter and 2 ft. 6 in. long. Temperatures up to 850° C. may be used for the copper slabs, whilst for brass slabs, for which the furnace is also used, the upper limit is around 750° C.

During the last year two normal frequency induction heaters have been supplied by Electric Furnace Co., Ltd., for reheating aluminium billets prior to extrusion. These each have an output of approximately ½ ton/hour. A third, whose installation is practically completed, is rated at 250 kW., with an output of 1,700 lb. of aluminium or magnesium billets per hour. It takes a balanced load on a 440 volt, 3-phase, 50 cycle supply, and is controlled by the extrusion press operator. When he is ready for a hot billet, a cold billet automatically charged from the magazine into the inductor coil pushes out a hot billet from the other end. The mechanism is operated pneumatically from customers' works air supply at 60 lb./sq. in. Four billet heaters of this type are in course of construction by the same company, each having an output of 5 tons/hour of brass and copper billets.



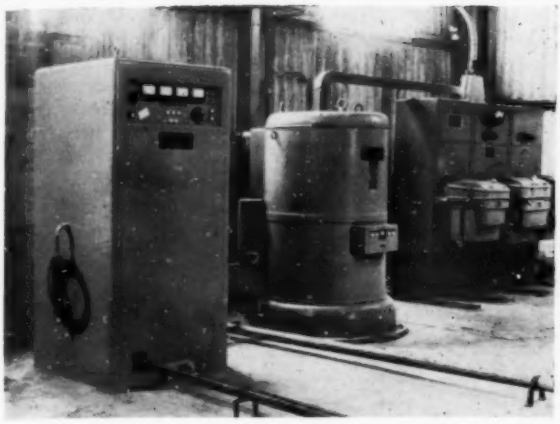
Courtesy of The Dowson & Mason Gas Plant Co., Ltd.

Fig. 6.—Transportable stress relieving furnace built at Livorno. Air heaters are shown along one side but gas and air piping is removed.



Courtesy of Electric Furnace Co., Ltd.

Fig. 7.—Equipment for stress relieving welds by induction heating.



Courtesy of Electric Furnace Co., Ltd.

Fig. 8.—The high frequency generator in connection with the equipment shown in Fig. 7.

Stress Relieving

Many components cannot be fabricated without acquiring, in varying degree, internal stresses, and to meet stringent rules and safety codes it is necessary to relieve these stresses. This is usually accomplished by heating the component throughout to a specified temperature and allowing it to cool slowly, in the furnace for preference. Stress relieving is a very important operation and necessitates accurate control of the temperature and rate of heating and cooling. Many types of furnace are used for this purpose, but that shown in Fig. 6 is exceptional, because it is believed to be the first of its kind to be designed and erected.

For the relief of residual stresses from boiler drums and other pressure vessels after welding, it has been the practice to use a car bottom or bogie furnace of a length sufficient to take the longest article likely to need stress relieving. There are obvious disadvantages to this practice. In oil refineries and atomic power stations there is a trend towards the use of increasingly large vessels and the stage is rapidly being reached at which road transport considerations require the vessels to be delivered in sections and heat treated after the various parts have been assembled and welded together at the site.

To meet the need for an improved construction of furnace for such conditions The Dowson and Mason Gas Plant Co., Ltd., has designed and built a transportable furnace, adjustable in capacity, which can be erected on site and, if necessary, removed to an entirely new position after use. The furnace shown in Fig. 6 has an internal length of 72 ft.; it was used to heat a vessel to a temperature of 550° C. at a rate of approximately 30° C./hour, followed by soaking for 10 hours, during which time the temperature uniformity was within 15° C. Full particulars about this interesting development would be beyond the scope of this review, but further information will be published in the near future.

Another method of overcoming the difficulties involved in stress relieving is the unusual application of induction heating shown in Fig. 7. This shows part of one of the heat exchangers which Babcock and Wilcox, Ltd., are supplying for the Calder Hall atomic power station. The construction of the heat exchanger involves site

Courtesy of Electric Furnace Co., Ltd.

Fig. 9.—Induction heating plant at Richardsons Westgarth (Hartlepool), Ltd., for stress relieving welds in high pressure steam piping.

welding of courses over 17 ft. in diameter to Class I standards. The welding on site of the circumferential seams involves preheating in the cold weather and stress relieving at 600°–650° C. For the stress relieving, flexible inductor cables of special construction are passed around the drums over an asbestos cloth and covered with further asbestos insulation held in place by non-ferrous plates clamped to the drums. Fig. 7 shows one weld with the equipment in position. The ends of the cables are brought to connection boxes in the floor connected by busbars to a high frequency generator rated at 200 kW., 2,500 cycles, shown in Fig. 8. Plant of similar character has been supplied to Richardsons Westgarth (Hartlepool), Ltd., in this country, Cie. Electro-Mecanique in France, and Brown Boveri et Cie. in Switzerland. Although normal frequency equipment can be used for this purpose, the use of high frequencies is justified by the ease of control and the simplicity of repeating time-temperature cycles over long periods.

The plant at Richardsons Westgarth, rated at 50 kW., is used for stress relieving welds in high-pressure steam piping. Fig. 9 shows the plant in operation on the butt weld joining a valve to a steel casting branch piece. The internal diameter of the pipe is 7 in. and the wall thickness approximately 1½ in.; four welds can be stress relieved at a time, two in parallel from each of the two heater stations. One of these can be seen in the background, the other being to the right of the control panel. The generator is housed in the room behind the control panel.

Annealing

Many types of annealing furnace, for both ferrous and non-ferrous metals, have been installed during the past year, but it is only possible here to mention some that can be regarded as typical. In Fig. 10, for instance, is shown the discharge end of a continuous brass strip

Courtesy of Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 10.—A continuous brass strip coil annealing furnace recently installed at Enfield Rolling Mills, Ltd.

coil annealing furnace recently installed at the works of Enfield Rolling Mills, Ltd., by The Wellman Smith Owen Engineering Corporation, Ltd. It is an oil fired, semi-muffle, low temperature recirculating furnace, with a capacity of 4½ tons of coils per hour to be heated from cold to 570° C. using either heavy fuel oil or gas oil. The furnace chamber is divided into two zones, a heating zone and a soaking zone, which are independent of each other, being separated by a door. The respective combustion chamber for each zone is built on top of the furnace. Each combustion chamber is equipped with a recirculating fan and a separate chimney. Most of the products of combustion are made to circulate round the cast iron muffle and up through the coils.

The stock to be annealed arrives at the furnace by an underground conveyor from the mill, and is delivered in coils of about 800 lb. each. These are discharged on to a lift, which on rising delivers the coils on to the tilting mechanism which upends them on to perforated trays, each carrying four coils ready to be pushed through the furnace. Four trays are accommodated in the heating zone muffle and six trays in the soaking zone. Automatic temperature control is employed in both zones, with automatic alarm should the temperature of the gases entering the circulating fan become excessive.

Courtesy of The General Electric Co., Ltd.

Fig. 11.—A new railcar furnace for bright annealing mild steel strip at the Diantony Works of B.M. Rolling Mills, Ltd.

For bright-annealing steel strip in lengths, a new G.E.C. railcar furnace installation has been carried out at the Diantony Works in Birmingham of B.M. Rolling Mills, Ltd. This furnace, which is of the horizontal batch type, is shown in Fig. 11. It has doors at both ends, and travels along rails to any one of four working positions, where the charge is mounted on the furnace base (Fig. 12) and sealed within a heat resisting steel hood. The charge is protected during the annealing process by an atmosphere of partially burnt town's gas.

This furnace provides temperatures up to 850° C. and is heated by heavy gauge nickel-chrome ribbon elements mounted in the roof, side walls and doors. Each of the four bases has a refractory hearth to support steel strip in lengths up to 7 ft., stacked to a width of 2 ft. and a height of 2 ft. A visual indication that the furnace has been accurately positioned over a base is given by a green lamp mounted on a nearby wall, and an aural alarm is incorporated to safeguard against accidental movement of the furnace before the control circuit connections are broken. The furnace temperature is automatically controlled and temperatures at two positions in each base can also be recorded.

The latest addition to the sheet and coil annealing plant at the Margam Works of The Steel Company of Wales, Ltd., is shown in Fig. 13. This plant, installed by Incandescent Heat Co., Ltd., now consists of 17 Lee Wilson lift-off type furnaces, each heated by radiant bowl type burners of special design. A further five furnaces are now in course of construction, which will bring the total plant up to 22 furnaces with 60 bases.

Courtesy of The General Electric Co., Ltd.

Fig. 12.—Stacking mild steel strip on a base for bright annealing in the G.E.C. railcar furnace.

An interesting electrically heated furnace for bright-annealing copper wire has been installed by Derby Cables, Ltd. (Fig. 14). Rated at 125 kW., it has an output of 102 tons of wire per week. The weight of the spools varies from 300 to 1,000 lb. each; they are delivered from the drawing machine direct to the furnace, and a tilting mechanism at each end of the latter automatically places the spools vertically on the conveyor chains. This furnace is designed for step-

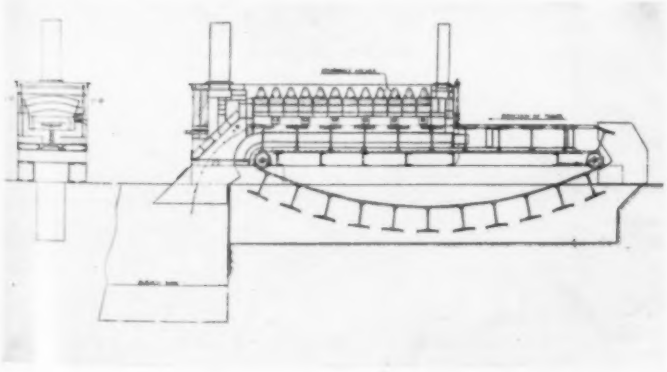
continuous operation, and it incorporates fully sealed entry and exit air-lock chambers. The atmosphere is derived from cracked and burnt ammonia, but exothermic plant is also used in other installations utilising town's gas, butane and propane.

Several continuous furnaces of the type shown in Fig. 15 have been installed for the treatment of high manganese steel plates. The furnace illustrated is gas heated and capable of a continuous output of 240 manganese steel plates per hour, varying in sizes from 17 in. to 20 in. square by 19 s.w.g., and heated to 1,070° C. Heating is effected by a series of gas and air blast burners, which are arranged to fire directly into the working chamber, the products of combustion being

Courtesy of Incandescent Heat Co., Ltd.

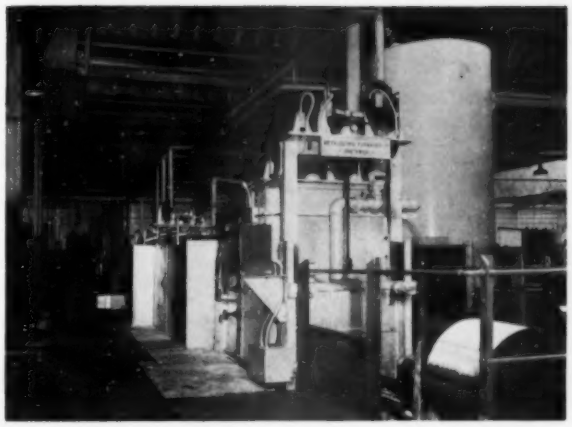
Fig. 13.—The latest addition to the sheet and coil annealing plant at the Margam Works of The Steel Company of Wales, Ltd.

exhausted from both ends of the furnace to ensure even heating conditions. The construction of the working chamber and the disposition of the burner equipment is such that there is no direct impingement of the flames on the plates. The continuous conveyor chain is remote from the direct heat of the furnace, but the work holders, which support the plates by point contacts, are constructed of heat resisting steel.



Courtesy of Brayshaw Furances & Tools, Ltd.

Fig. 15.—A diagrammatic view of a continuous furnace for the treatment of high manganese steel plates.



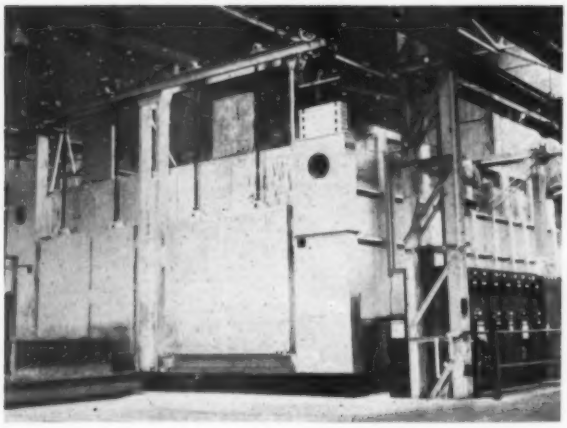
Courtesy of Metalectric Furnaces, Ltd.

Fig. 14.—Furnace installed by Derby Cables, Ltd., for bright annealing copper wire.

Among new plants involving bell-type furnaces, is an electrically heated installation in the works of Shepcote Lane Rolling Mills, Ltd., for batch softening of coiled stainless steel strip of 17% chrome quality at approximately 780°–800° C. The coils are heat treated after they have been hot rolled and welded together to form units of up to 10,000 lb. in weight. Hot rolling reduces the strip to about 0·125 in. in thickness and, after softening in the furnace, it is cold rolled down to the particular gauge required. This furnace is of the lift-off type, and the complete plant comprises two charge bases, a slow cooling hood, automatic temperature control equipment, switchgear, and an oil circuit breaker. The heating bell is rated at 220 kW. distributed over a

Courtesy of G.W.B. Furnaces, Ltd.

Fig. 16.—A new bell-type furnace for batch softening of coiled stainless steel strip in coils up to 10,000 lb. in weight.



Courtesy of G.W.B. Furnaces, Ltd.

Fig. 17.—Large twin-chamber furnace for annealing aluminium strip in coils.

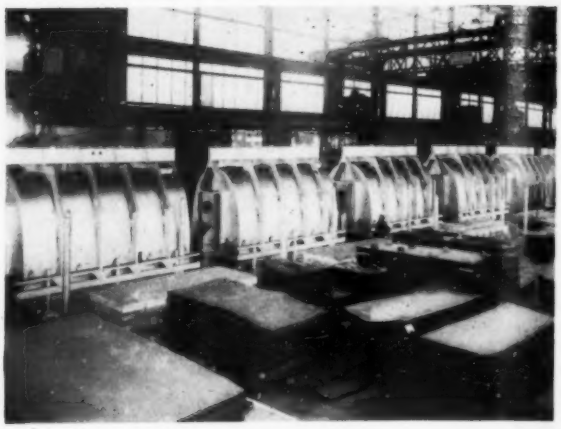
single automatically controlled zone. Each of the two bases carries two coils of stainless steel strip with a total maximum weight of approximately 20,000 lb. The normal process cycle covers a total of 14 hours, which includes a soaking period of 2–4 hours. Fig. 16 shows the heating bell raised with the charge in position.

A large twin-chamber annealing furnace (Fig. 17) has recently been completed by G.W.B. Furnaces, Ltd., each chamber of which is 36 ft. long, 9 ft. wide and 7 ft. high. This furnace is designed to accommodate 20 coils of aluminium strip, each 3 ft. 6 in. outside diameter by 10 in. wall thickness by 4 ft. 6 in. high, and weighing 4,000 lb. Each chamber is rated at 1,000 kW., divided into six automatically controlled zones. Star/delta switching is included to reduce the furnace input when equilibrium at soaking temperature has been reached. A series of high speed air-circulating fans is fitted in the roof of each chamber to speed up heating of the charge and to obtain a high degree of thermal uniformity.

Joseph Sankey and Sons Ltd., have recently installed

Courtesy of Birlec, Ltd.

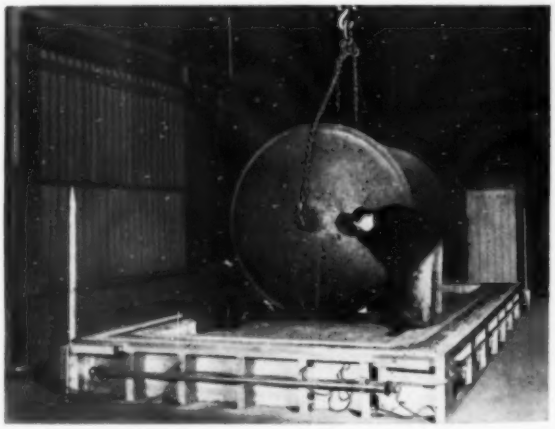
Fig. 19.—A battery of six 250 kW end-flow furnaces for the treatment of aluminium coils installed by Imperial Chemical Industries, Ltd., Waunarlwydd, South Wales.



Courtesy of Birlec, Ltd.

Fig. 18.—A battery of six 180 kW lift-off bell furnaces for the treatment of silicon steel sheet.

six Birlec lift-off bell furnaces for the treatment of silicon steel sheet. The silicon steel, which is treated in both flat and coil, is intended for use as low-loss electrical transformer sheet. The heat treatment operation involves temperatures up to about 1,100° C. and special



Courtesy of The Dowson & Mason Gas Plant Co., Ltd.

Fig. 20.—A steel vessel being loaded on to a furnace base at Towler & Son, Ltd., preparatory to covering with a hood sealing and annealing.

features have been incorporated in the furnace design to meet these conditions. As will be noted in Fig. 18, the furnace bodies are parabolic in shape, this section providing the maximum constructional strength at heat, and also ensuring a high degree of temperature uniformity throughout the charge. Each furnace is rated at 180 kW., and the heating elements are of nickel-chrome strip arranged in two zones. There are two hearths per furnace to make full use of the heating potential of the equipment. After a charge has reached a sufficiently low temperature in its cooling cycle to prevent oxidation on exposure to the air, the furnace bell is transferred to the companion hearth where it heats up a fresh charge. The first charge is then covered with a sheet metal

hood to which a supply of protective atmosphere is maintained. The non-oxidising furnace atmosphere is obtained from an I.C.I. ammonia gas generator comprising a standard cracker, with catalyst, and a regenerative ammonia burner. To achieve the low dew-points required, the atmosphere is passed through standard Birlec Lectrodryers, one to each furnace. The control instruments are of Kent manufacture, each zone being provided with a combined indicating controller and programme regulator.

Fig. 19 shows six end-flow furnaces which have been installed at the works of Imperial Chemical Industries, Ltd., Waunarlwydd, South Wales, for the heat treatment of aluminium coils; they are electrically heated and each rated at 250 kW.

Courtesy of The General Electric Co., Ltd.

Fig. 21.—A bell furnace installation for bright annealing copper wire in coils.

In boiler and steel fabrication shops there is a need for furnaces operating in the range of 500°–650° C. for stress relieving, but temperatures up to 950° C. may be required for general annealing and normalising purposes, and the portable cover furnace has gained popularity. One of its advantages is the control of cooling, which can be obtained by lifting the hood and placing it on steel bars at the corners. This permits fairly slow but more uniform cooling, and by varying the height of opening the rate can be adjusted to suit the particular treatment. Such a furnace, illustrated in Fig. 20, was recently installed at the Stratford Works of Messrs. Towler and Son, Ltd. It has a hearth measuring 7 ft. 6 in. by 16 ft. 9 in., with a hood 8 ft. from base to crown.

A new G.E.C. bell furnace has been installed at the Eastleigh Works of Pirelli-General Cable Works, Ltd. This furnace, shown in Fig. 21, has three bases and hoods and the installation includes automatic temperature control and recording gear and controlled atmosphere plant. Rated at 75 kW. the furnace takes a charge of spools weighing about 1,800 lb., and the heating time averages 1½ hours. Coils of wire are stacked on the bases and sealed within a cylindrical hood. The gas-tight seal between hood and base is effected by embedding the former in a channel carrying a low-melting-point alloy initially melted with steam. After the hood has been purged of air, the furnace bell is lowered and accurately positioned by means of guide posts. Protective atmosphere is provided by a G.E.C. town's gas burner capable of delivering about 300 cu. ft. per hour.

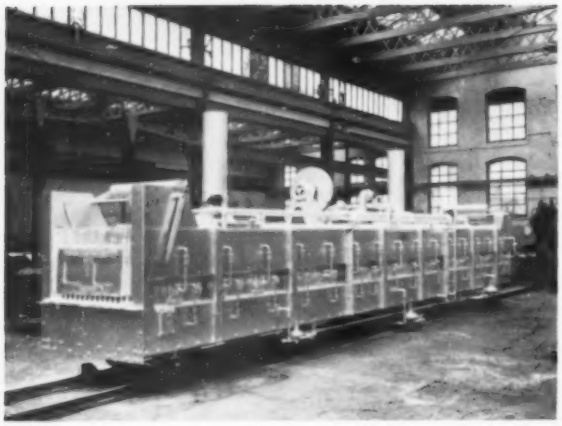
Courtesy of Modern Furnaces & Stoves, Ltd.

Fig. 22.—A bogie-type annealing furnace incorporating Vortex burners.

In the bogie type annealing furnace shown in Fig. 22, an important feature of design is the exhaustion of waste gases through openings in the centre of the bogie. In conventional designs, with exhaust ports in the side walls, the gases are short-circuited, passing along the side walls and roof to the exhaust ports. This causes a temperature lag in the centre of the load, with subsequent increase of heating time and gas consumption; the design of the furnace shown gives rapid heat penetration of the whole load and uniform temperature throughout. The collars for sealing the ducts from the bogie to the main flue, are operated by a single hand wheel at the front of the bogie, and the opening into the downtakes through the bogie are protected from damage by cast steel rings. Exhausting through the hearth is important for low as well as high temperature operation, and offers advantages for stress relieving at low temperatures, where heat transmission by radiation is not so effective. The Vortex burners, with which this furnace is fitted, are particularly suited for direct

Courtesy of The General Electric Co., Ltd.

Fig. 23.–Avertical cylindrical furnace installation for bright annealing 6-ton charges of carbon steel strip in coils.



Courtesy of The Dowson & Mason Gas Plant Co., Ltd.

Fig. 24.—A new gas-fired wire patenting furnace.

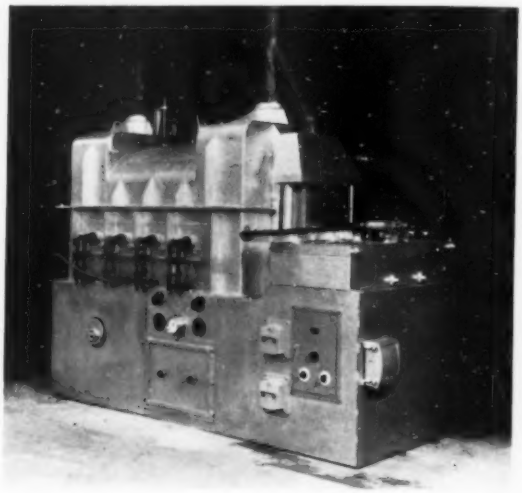
heating, because the combustion takes place within the large cone of the quarl, and the products of combustion enter the heating chamber at a comparatively low velocity, so that no impingement on the load takes place.

A vertical cylindrical furnace for bright annealing 6-ton charges of carbon steel strip in coils has been installed at the works of The Stourbridge Rolling Mills, Ltd. Five annealing containers are used with this furnace, to permit a continuous cycle of operations which includes, in addition to the heating and cooling of the strip, a system of heat recuperation whereby heat from the charged container removed from the furnace is used to preheat one newly charged. This preheating is carried out in a brick-lined enclosure where the hot and cold containers are placed side by side. The complete plant is shown in Fig. 23. It is noteworthy that each of the containers has a fan mounted in the lid to increase the circulation of the controlled atmosphere around the coils, and so to reduce heating time in the furnace.

Several improvements have been made, in recent years, in the tubular and open types of wire patenting furnaces and, in general, these have had the effect of increasing the quantity of wire to be treated per hour in any given furnace length, while maintaining the quality of the treated material. Multi-zone temperature control and high capacity burners at the inlet end give very much faster heating rates than was thought possible a few years ago. A typical example, which deals with 24 wires at a time in a chamber 2 ft. wide and 36 ft. long, is illustrated in Fig. 24. This furnace is mounted on roller bearing wheels so that it can be moved along the patenting shop to allow incorporation of other equipment in the line at a later date. As the working temperature can be raised from cold in two hours, there is no need to keep the furnace at temperature during week-ends.

Courtesy of Electric Resistance Furnace Co., Ltd.

Fig. 25.—Part of an EFCO installation for patenting and galvanising steel wire.



Courtesy of Brayshaw Furnaces & Tools, Ltd.

Fig. 26.—A pusher type furnace, incorporating self-contained controlled atmosphere plant, designed to meet the requirements of the aircraft industry.

In an electrically heated installation (Fig. 25), the patenting furnace is of the 20-wire type, and has a heating chamber 40 ft. long by 2 ft. wide. The rating is 150 kW. and the temperature is controlled in four separate zones through stepdown transformers. When handling 1 to 10 s.w.g. rod, the output is 9 cwt./hour. The lead bath tank size is 10 ft. by 4 ft. by 2 ft. deep and its rating is 60 kW. It is fitted with electric immersion heaters and cooling tubes with an air blower. Guide rollers are provided at both ends along with a counter-balance sinker roller. The electrical control equipment cuts off power to the heaters at a temperature just below the control setting, and the cooling system is automatically brought in at a temperature just above the control setting. An electrically heated galvanising bath, complete with flux drying oven has been supplied for use with this installation, the 10 ft. by 3 ft. by 22 in. deep bath being rated at 70 kW.

Hardening and Tempering

To meet the varied requirements of the aircraft industry for furnace plant suitable for the continuous heat treatment of turbine components, several different designs have been supplied of the conveyor and pusher types, both gas and electrically heated. A typical installation is shown in Fig. 26, which is of the pusher type, is gas heated and incorporates a self-contained controlled atmosphere plant. It carries a complete

Nimonic muffle and has inside dimensions 9 in. wide by 10 in. high, and a heating length of approximately 5 ft. It is designed to maintain a continuous output of parts delivered at the rate of 360 (average weight 140 lb.) per hour at a temperature of 1,180° C. The furnace pusher gear, comprising pneumatically operated twin pusher arms, operates on a compressed air supply of at least 60 lb./sq. in. An automatic process timer operates in conjunction with the twin pushers, which are arranged to work alternately and deliver one part at a time into the heating muffle.

A plant for the heat treatment of low alloy steel castings has been installed at the Pallion Steel Works

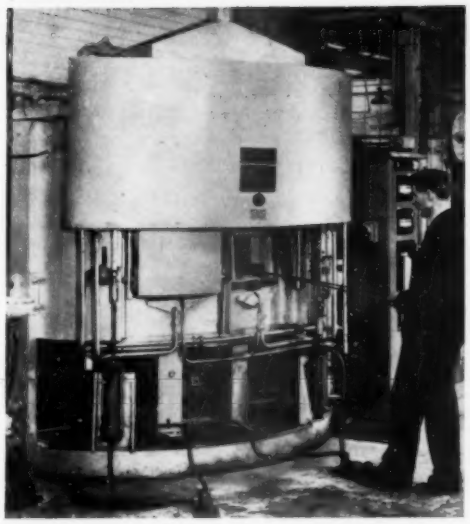
Courtesy of E. Jopling & Sons, Ltd., and Gibbons Brothers, Ltd.

Fig. 27.—The recently-installed plant at the Pallion Steel Works of E. Jopling & Sons, Ltd., which is being used for the treatment of low alloy steel castings of various specifications.

of E. Jopling and Sons, Ltd. but it is expected that manganese steel and high alloy steels will also be treated. This steel foundry averages about 100 tons/week of small to medium sized steel castings, a proportion of which subsequently pass to the new heat treatment shop. At present, the plant installed comprises the heat treatment furnace, charging machine and a quenching machine using water, but the foundations have been prepared for similar equipment using oil, and for a further furnace. The existing plant, shown in Fig. 27, was installed by Gibbons Brothers, Ltd.

The furnace has a heating chamber 8 ft. 6 in. long by 6 ft. wide by 4 ft. high. It is fired by town's gas, using top and bottom Eddy Ray burners, and is designed for temperatures up to 1,000° C., Electroflo temperature control equipment being fitted. The charging machine is of the Gibbons-Van Marle turntable type; fitted with three arms and designed to carry up to 3 tons it can swing through an arc of 270° to facilitate unloading. The quenching machine is designed to take a load from the charging machine and quench it immediately in oil or water. The plant at present is designed for water quenching but can be turned over to oil with the addition of a cooler. The castings are deposited on a table which submerges to effect the quench. The tank is fed with water from a high pressure main, and has a capacity of 4,000 gallons which can be changed six times each hour.

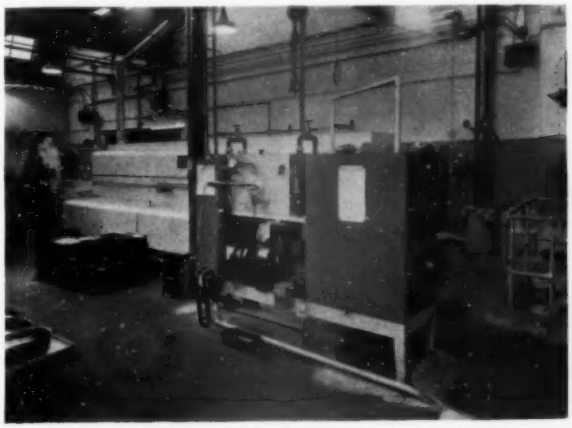
A very different design of furnace for hardening steel castings is that shown in Fig. 28. This is a rotary hearth



Courtesy of The General Electric Co., Ltd.

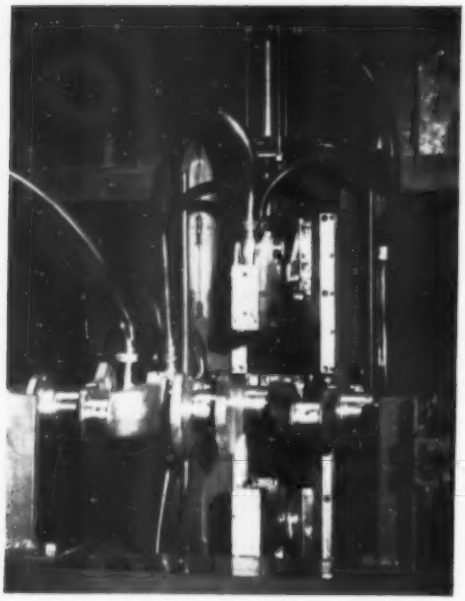
Fig. 28.—A rotary hearth furnace for hardening steel castings.

furnace which has recently been installed at the works of a well-known firm manufacturing aircraft components. This unit provides temperatures up to 1,000° C. and has a hearth 12 in. wide, with a mean diameter of 4 ft., rotating on roller bearings. The hearth is driven by a squirrel cage induction motor through reduction gears. Charging and discharging doors, each opening 13 in. wide and 10 in. high, are arranged side by side; they are operated pneumatically by single pedal-operated valves so that they stay open only while the pedals are depressed. As the furnace is arranged for use with a controlled atmosphere, the door faces and frames are machined to make a gas tight seal. A sand seal is effected between the hearth and the furnace casing. The heating elements are mounted in the inner and outer walls and are arranged in two zones, each with its own independent automatic temperature



Courtesy of G.W.B. Furnaces Ltd.

Fig. 29.—Continuous furnace for the hardening of steel bolts.

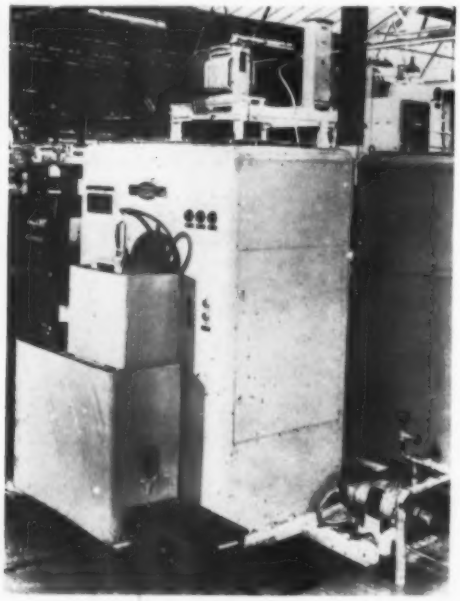


Courtesy of Electric Furnace Co., Ltd.

Fig. 30.—Using induction heating for hardening crankshaft journals. The illustration shows the inductor with its quench holes and operating cylinders and a crankshaft in position for hardening one of the pin journals.

control gear. This furnace will handle an output of 200 lb. of castings per hour.

The latest installation of one of G.W.B.'s standard continuous hardening furnaces is shown in Fig. 29. In this case, the unit is used for hardening 5 cwt. of bolts

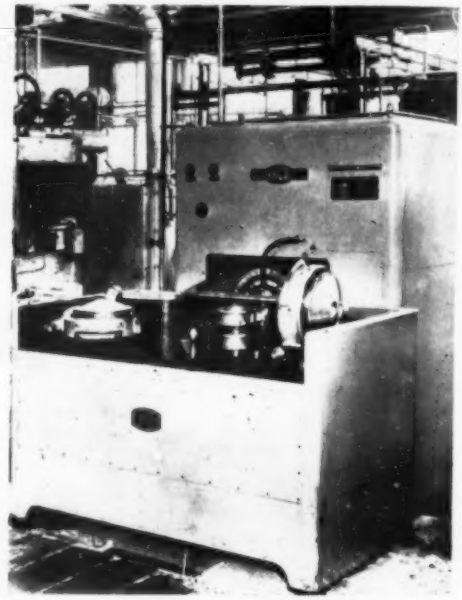


Courtesy of Electric Furnace Co., Ltd.

Fig. 31.—The pin-hardening station, applying the induction hardening technique, at the Doncaster Works of the International Harvester Co. of Great Britain, Ltd.

per hour, the furnace rating being 105 kW., divided into two automatically controlled zones. At the discharge end of the furnace the bolts drop off a mesh belt conveyor through a sealed chute into an oil quench, from whence they are removed by means of a continuous extractor mechanism. A protective atmosphere from a standard G.W.B. exothermic plant prevents scaling and decarburisation.

The first commercially successful application of high frequency induction heating, as distinct from melting, was the hardening of crankshaft journals. As is generally known, the process was developed by the Ohio Crankshaft Company to withstand the higher stress imposed on their crankshafts in diesel engines. The first installation of this type in this country was made in 1936 at the works of Ambrose Shardlow and Co., Ltd., Sheffield, and an improved installation, capable of



Courtesy of Electric Furnace Co., Ltd.

Fig. 32.—The track roller station, at the same works, is provided with two rotating spindles on which the rollers are mounted.

dealing with a much larger output was made there in 1949. This installation, however, still involved a considerable amount of handling, and the design has been changed to enable a large degree of mechanisation to be incorporated.

The crankshafts are mounted between centres on a trolley brought along rails in front of the heater station. The station is provided with sufficient inductors to harden all the journals, and the former are moved into position in turn. Closing of an inductor around the journal automatically switches high frequency current on to that inductor for a predetermined time, followed by a spray quench, also for a predetermined time. Fig. 30 shows the inductor with its quench holes and operating cylinders, and a crankshaft in position for hardening one of the pin journals. After all the journals have been hardened, the crankshaft trolley is moved on the station and the crankshaft is transferred to a tempering furnace.

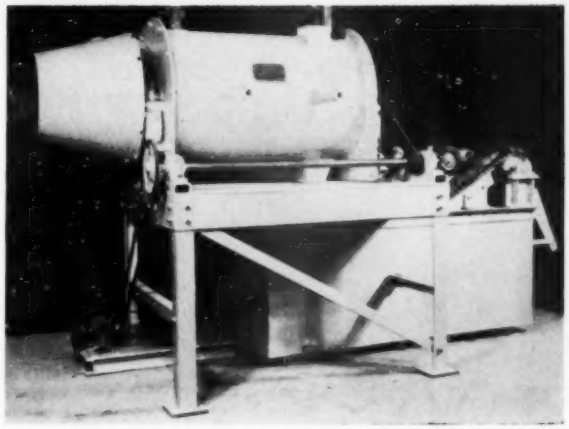
All the operations between loading the crankshaft on to the trolley and unloading it after treatment are carried out automatically, including adjustment of the time cycle and alteration of the power applied according to the requirements of the individual journals. The trolleys are also returned to the loading point automatically.

A further application of the induction hardening technique may be seen at the Doncaster works of the International Harvester Company of Great Britain, Ltd. A 150 kW. 10,000 cycle motor generator may be connected through interlocked selector switches to one of several heater stations, three of which are illustrated in Figs. 31, 32 and 33. The pin hardening station, Fig. 31, is of the progressive type, the pins being loaded one at a time in the charging chute, whence they are passed downwards through inductor and quench at a controlled speed. The track roller station, Fig. 32, is provided

Courtesy of Electric Furnace Co., Ltd.

Fig. 33.—Showing the gear station, each gear to be hardened being lifted by retractable claws into the inductor.

with two rotating spindles on which the rollers are mounted. One spindle, together with its roller, is swung in towards the inductor, when power is applied for a predetermined time. A manual lever swings this roller into one of the two quench positions, at the same time moving the second spindle on which the roller has been mounted into the inductor. The quench is also time-controlled through a solenoid-operated valve. In the gear hardening station, Fig. 33, the gears are loaded one at a time on to a platform, which is moved by hand under a spindle provided with retractable claws. The gear is lifted by the claws into the inductor, where it is rotated and heated for a predetermined time before being lowered into an oil quench bath. The platform has meanwhile been returned to the loading position to take the next gear, when the cycle is repeated. The quenched gear is removed from the oil tank by conveyor and discharged on the other side.

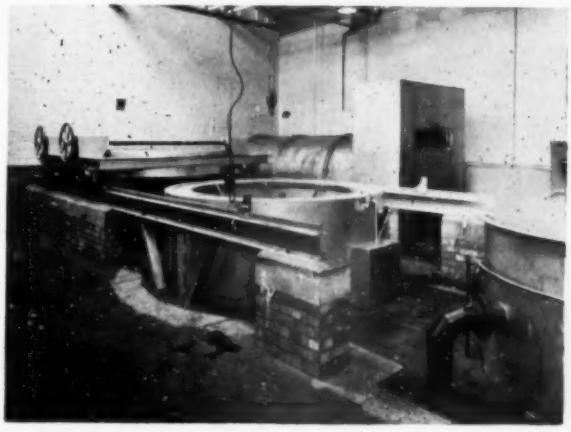


Courtesy of Braybaw Furnaces & Tools, Ltd.

Fig. 34.—A rotary retort-type furnace for treating small parts.

Many furnaces have been specially designed for dealing with small parts. Of these, the rotary retort type has a number of advantages, especially when used for such products as screws, etc. One of the many installations supplied is a gas heated scroll type of rotary retort furnace, which is shown in Fig. 34. This is hopper fed, the parts being treated passing automatically into and through the scroll retort, before being ejected by a chute into an oil bath provided for the quenching operation. The quench tank is provided with a conveyor device with an elevator which extracts the quenched parts. The furnace retort is of nickel-chrome heat-resisting steel, and is 8 in. in diameter by 4 ft. long.

For the heat treatment of aluminium alloy components a new G.E.C. forced air circulation furnace has been installed. This unit shown in Fig. 35, is 5 ft. in diameter and 5 ft. 10 in. in depth. Mounted in the base of the furnace is a fan which drives the air continuously over the heating elements and round the charge. The quench tank is 7 ft. 6 in. in diameter and 8 ft. 6 in. deep, and will take 3 cwt. of components in a basket. The quench-



Courtesy of The General Electric Co., Ltd.

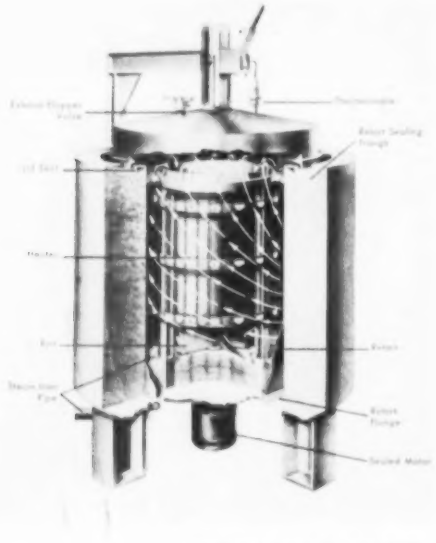
Fig. 35.—A forced air circulation furnace for the heat-treatment of aluminium alloy components.

Courtesy of Metalectric Furnaces, Ltd.

Fig. 36.—A new installation at Garringtons, Ltd., comprising over 40 furnaces for the treatment of gas turbine blades in such materials as Nimonic, aluminium bronze, and light alloys.

ing water is heated to 95° C. by means of steam pipes, and maintained at that temperature by thermostatic control.

A rather comprehensive plant has been installed by Garringtons, Ltd., for the treatment of turbine blades in materials including Nimonic, aluminium bronze, and aluminium alloys. This Metalectric installation, which comprises over 40 furnaces, includes rotary hearth forging furnaces, rotary table forging furnaces, end heating furnaces, pit-type tempering furnaces, pit-type solution treatment furnaces, and ageing furnaces. All these furnaces have fully automatic temperature control equipment fitted. The illustration Fig. 36, shows 10 low temperature pit-type ageing furnaces, each rated at 30 kW. and having internal basket dimensions 32 in. deep and 32 in. diameter.

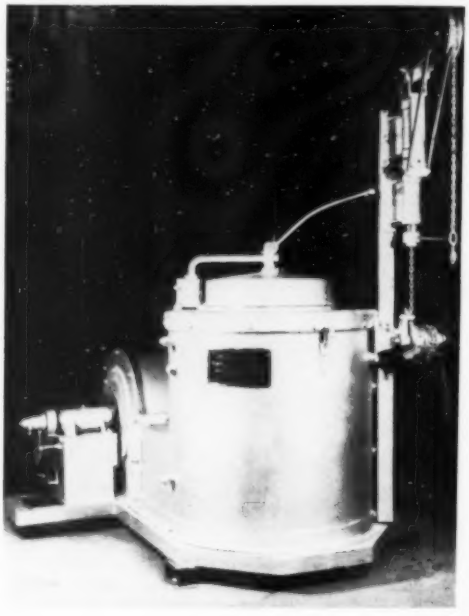


Courtesy of Integra, Leeds & Northrup, Ltd.

Fig 37.—A steam Homo furnace for scale-free heat treating of ferrous and non-ferrous components.

A general utility furnace, which has been increasingly applied during the past year, is that manufactured by Integra, Leeds and Northrup Ltd., Birmingham, and which utilises the Steam Homo method of treatment. This is a highly versatile technique which provides scale-free heat treating for both ferrous and non-ferrous components at temperatures up to 620° C. When applied to steel components, the furnace is first brought to a temperature of 370° C. with normal atmosphere, then held at this temperature for about half-an-hour while steam is injected to purge air from the work chamber. The load is then heated to soaking temperature and held for the specified time, with steam flowing through the furnace. At the end of the soak, work is either air cooled or quenched in soluble oil. For non-ferrous work requiring lower soaking temperatures, the furnace may be purged at as low as 200° C. and the parts are often quenched in water.

While this method is applied to annealing and stress-relieving operations with great success, steam atmos-



Courtesy of Brayshaw Furnaces & Tools, Ltd.

Fig. 38.—A recently-developed recirculation-type furnace for treatments at low temperatures, specially designed for tool room use.

phere tempering by this method has also been shown to provide many advantages. When hardened steel components are tempered or stress relieved in steam atmosphere, they come out clean and free from scale. Steam protects them during treatment, forming on them a tightly adherent oxide coating which makes an attractive final finish. Drills, reamers, hobs, milling cutters and other high speed steel cutting tools hold their cutting edges 25% longer when steam-treated following tempering and final grinding; this advantage increases when cutting tough materials. The complete furnace for this treatment is shown in Fig. 37.

Other standard Integra heat treatment furnaces make use of the Homocarb method with Microcarb atmosphere control, which gives heat treaters full

automatic control of both temperature and furnace atmosphere during carburising and hardening; the Vapocarb-Hump hardening method, which permits the hardening of tools and dies without scale, decarburisation or distortion; and the Homo nitriding method.

Brayshaw Furnaces and Tools, Ltd. have designed a standard range of recirculation furnaces especially intended for tool room and other uses. Such a standard

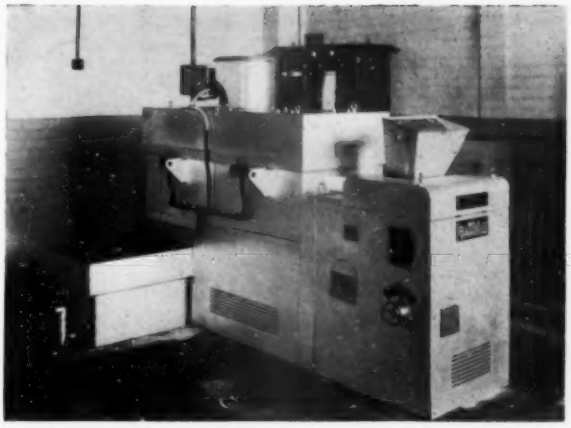
Courtesy of The General Electric Co., Ltd.

Fig. 39.—A new instrument developed for measuring the quality of carburising atmospheres suitable for use with several furnaces.

unit is shown in Fig. 38. In this furnace the heating of the charge is effected by the high velocity recirculated products of combustion. The components for precision heating are loaded into a container and charged into the furnace. Using town's gas, the burners fire directly into the combustion chamber, which is separate from the work chamber, and the hot products generated are circulated through the work chamber by means of a fan incorporated in the combustion chamber. This type of furnace gives uniformity of heat penetration and the atmosphere can be controlled to reducing or oxidising as may be required. The furnace illustrated has a work container 16 in. diameter and 16 in. deep, and has an effective operating range of 150°–700° C.

Carburising and Carbonitriding

In some heat treatment processes the quality of the furnace atmosphere is important, particularly in such processes as the hardening of medium or high carbon steels, where decarburisation is to be avoided, the restoration of carbon to surfaces of parts which have been decarburised during working or heat treatment, and the carburising of steel surfaces to some specific carbon content. It is of interest to note, in this connection, that a new instrument for



Courtesy of Wild-Barfield Electric Furnaces, Ltd.

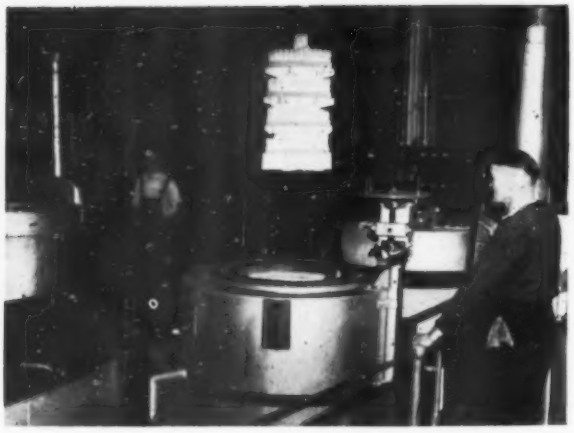
Fig. 40.—A shaker hearth furnace for the continuous carbonitriding of small components.

measuring the quality of carburising atmospheres has been developed by the General Electric Co., Ltd. This carbon gauge consists essentially of a compartment having a transparent front and enclosing an iron wire which is carburised in the atmosphere under test and cooled rapidly so that it is transformed to martensite. In this condition, the electrical resistance of the wire is a measure of its carbon content, and hence of the carburising potential of the atmosphere. Values of the electrical resistance of the quenched wire can be directly related to carburising potential from a calibration curve. Operation of the gauge is straightforward and a measurement takes about 15 minutes. Both panel and portable gauges are available, the latter being shown in Fig. 39.

The continuous carbonitriding of small components is conveniently carried out in the shaker hearth type of furnace, such as the installation shown in Fig. 40, which is used for dealing with small automobile petrol pump parts. Tubular heating elements are arranged for

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 41.—A "Carbodrip" installation, showing the general layout on the left, with a close-up of the standard unit designed to supply the "Carbodrip" fluid for gas carburising on the right.



Courtesy of Burman & Sons, Ltd.

Fig. 42.—Part of a battery of four gas carburising furnaces by Incandescent Heat Co., Ltd., each heated by "Jetube" radiant heating elements.

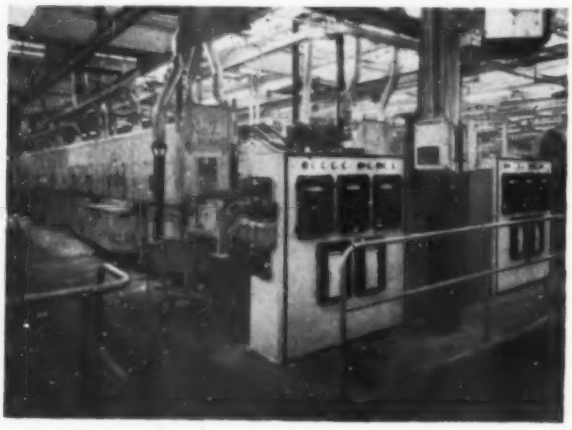
two-zone control, and a centrifugal fan in the roof ensures circulation of the carbonitriding atmosphere, thus giving consistent heat treatment. Rearward action of the hearth tray is by means of a suitable cam driven through reduction gear and variable speed drive; forward movement is by coil springs. The design of the hearth is such that positive and controlled progression of components through the furnace is assured.

For many years Wild-Barfield Electric Furnaces, Ltd., have adopted their town's gas system for gas carburising, with excellent control of case depth and type of case; comparable results are now available using the Wild-Barfield Carbodrip system of drip-feed gas carburising. Fig. 41 shows the general layout of an installation and an enlarged view of the standard unit designed to feed the Carbodrip fluid to the furnaces. The container, holding approximately 10 gallons, is fitted with a well-protected sight glass, and the unit also carries a combined automatic pressure regulator relief valve and water trap, a pressure gauge, and a filler cap. Positive indication of the rate of flow is provided by an indicating flow meter.

Part of a battery of four gas carburising furnaces is shown in Fig. 42, each of which is heated by Jetube radiant heating elements. Installed by Incandescent Heat Co. Ltd., in the Birmingham works of Burman and Sons, Ltd., the equipment includes an endothermic gas generator which provides the atmosphere for these furnaces. When the furnaces reach carburising temperature, the carburising medium, Lithanol, is injected into the carrier gas stream, which not only gives uniform case depth and surface, but also provides a protective coating to the surface of the work to prevent oxidation whilst at temperature. The plant includes two quench tanks, control panel for each furnace, and specially designed nickel-chrome jigs to carry the work.

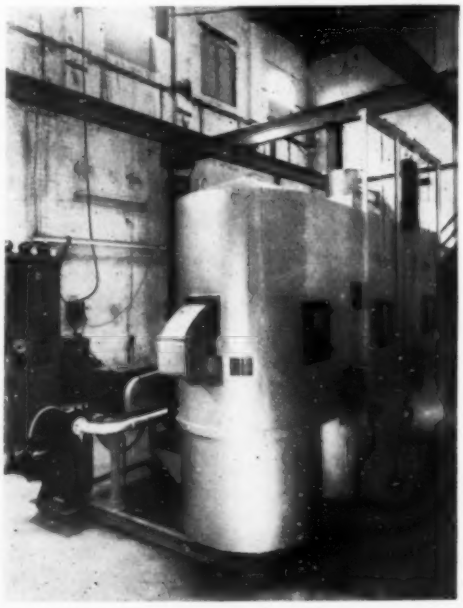
Salt Baths

In previous reviews, reference has been made to developments in the use of salt baths for heat treatment, involving reduced costs of operation and improved working conditions for operators. Progress has continued along these lines, and the trend is towards increased application for salt bath processes; of these, mention may be made of deep carburising, and of the processes for austempering and martempering. In particular, installation of mechanised and fully automatic salt bath furnaces for the handling of large quantities of small- or medium-sized parts is on the increase.



Courtesy of Imperial Chemical Industries, Ltd.

Fig. 43.—Two "Cassel" "C.A." type automatic furnaces for casehardening automobile parts in the cyanide/carbonate bath at 900° C., to a depth of 0·010/0·025 in.



Courtesy of Imperial Chemical Industries, Ltd.

Fig. 44.—"Cassel" fully-automatic type "D.G." plant used for casehardening small parts which can be poured from one container to the next.

From a number of recent installations, five have been selected to show the trend of development. Fig. 43 illustrates two automatic salt bath furnaces installed

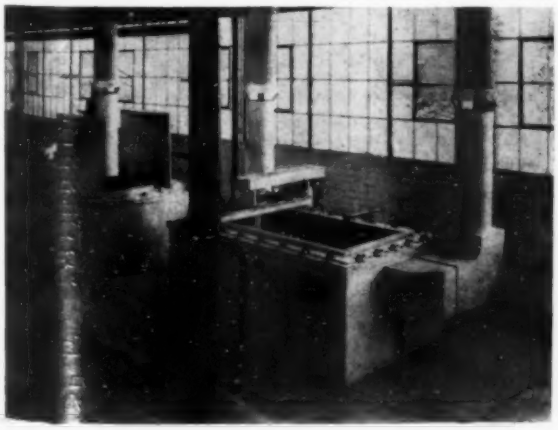
Courtesy of Imperial Chemical Industries, Ltd., and The Aldridge Tool & Engineering Co., Ltd.

Fig. 45.—Layout of salt bath furnaces for hardening high speed steels and hot die steels.

side by side, and used with cyanide-carbonate baths for applying case depths up to 0·025 in. to automobile components made in alloy or carbon casehardening steels. Further installations of the fully automatic furnace shown in Fig. 44 have been made. This type of salt bath furnace is particularly suitable for case-hardening small parts which can be poured from one container to the next through the successive stages of treatment, including preheat, salt bath, quench and discharge.

Salt baths have attained a high reputation for hardening high-speed steel and hot-die steel and a new plant, including several salt baths for hardening these steels, is shown in Fig. 45. Large die blocks for the drop forging industry are being made to-day to closely controlled dimensions, either by conventional die-sinking methods, or the newer process of "hobbing." Salt baths are specially suited for austenitising these die blocks, free from scale and decarburisation, and, if the quench is also done in salt by the "martempering" process, distortion is held to a minimum and cracking dangers are much reduced. A large plant installed within the last twelve months for treating die blocks is shown in Fig. 46; it includes a gas furnace for austenitising, and two furnaces of similar design, one fitted with a propeller agitator for martempering, and a second for tempering the die blocks subsequently.

The salt bath furnaces mentioned above are gas heated, but, while gas heating for these furnaces predominates, as we have indicated in previous years, electrode furnaces have several advantages. This form of heating produces agitation of the salt automatically, and allows the bath to be restarted from the solid state; the value of internal heating is also appreciable when the question of pot life is considered. While the advantages of electrode salt bath furnaces are known, their use has been somewhat restricted to those works which can maintain them in continuous operation. In



Courtesy of Imperial Chemical Industries, Ltd.

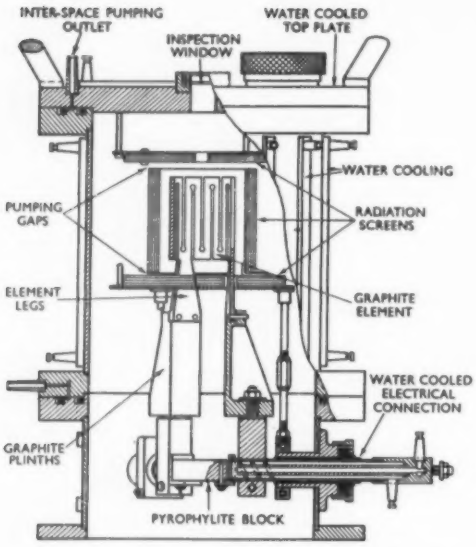
Fig. 46.—Salt bath plant for treating large drop forging dies.

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 47.—A small self-contained electrode salt bath designed to be economic both in continuous and in intermittent operation.

small works, where output is not high enough to take full advantage of their potentialities, production electrode salt baths may be uneconomic. It is noteworthy, therefore, that a small self-contained electrode salt bath has been developed which is designed to be economic both in continuous and in intermittent operation. This new equipment, shown in Fig. 47, is available with either a metal or refractory pot, interchanging providing no difficulty when necessary. It has a nominal rating of 12 kW. and takes approximately an hour to attain 1,300° C.

The electrical equipment includes a tapped transformer, main switchgear unit, main tapping switch, energy regulator, ammeter, pilot lights and interlocks. The controls are mounted on the sloping control panel



Courtesy of The General Electric Co., Ltd.

Fig. 48.—Section through a G.E.C. high temperature furnace in which the element is designed for operation on a three-phase supply.

seen in the illustration, and are grouped for maximum convenience. For temperature indication, a fixed focus radiation pyrometer is available, the receiving tube being mounted above the bath and the indicator above the control panel. An extracting fan takes care of the fumes.

Special Furnaces

The development of relatively new alloys and improvements in heat treatment technique increase the range of applications and may involve the development of special designs to meet special needs. In this connection it is of interest to note that the General Electric Co., Ltd., have developed a simple, robust furnace for such applications as the sintering of carbides and other refractories, and the specialised heat treatment of titanium, zirconium and tantalum, requiring temperatures above 1,800° C. Two models have been produced, one for single phase and the other for three phase supplies, a sketch of the latter being shown in Fig. 48. Both these furnaces employ cylindrical graphite resistor heating elements and are designed for vacuum operation. A temperature of 2,000° C. can be maintained with a loading of less than 6 kW. and an uncharged furnace reaches a steady temperature within 15 minutes of switching on at full power.

In our June, 1954 issue, reference was made to a furnace of hump-back design of particular interest in the powder metallurgy field for sintering or annealing. This furnace, which is designed and built by A. R. Wade, Ltd., Aldershot, is being applied in a variety of industries because of the advantages the hump-back design offers. Further developments by this firm are in progress, but are not sufficiently advanced to be included in this review; they concern a new furnace design whose purpose has not yet been disclosed.

It is noteworthy that another company has been formed, which is concerned with the design and manufacture of electric furnaces. It is Sintering and Brazing Furnaces, Ltd., with works at Slough and offices at Terminal House, Grosvenor Gardens, London, S.W.1. This company has been formed for the manufacture of equipment for a variety of heat treatment operations, particularly in connection with sintering and brazing. Present designs include furnaces of the conveyor, high-temperature, and hump-back types.

Conclusion

It has only been possible to present a few typical examples from the wide range of heat treatment plant and equipment installed during the past year. Due to pressure of work, some important furnace manufacturers have been unable to supply details of their developments in time for publication in this survey, but, despite these unavoidable omissions, there is ample evidence that designers and builders of heat treatment plant are continuing the progressive trends that have been so noticeable since the end of the war. Furnaces and equipment of a very high order are now available, indeed, many can be classed as precision tools, but, while these modern appliances have greatly advanced the art of heat treatment, the increasing demand for materials and components, having widely different properties, calls for operators of considerable skill and experience.

Acknowledgments

We are greatly indebted to those firms who have supplied information and photographs, and take this opportunity of expressing our grateful appreciation to them, and to the firms in whose works the various items of plant are installed for permission to publish the details and illustrations.

Higher Fees for Trade Marks

HIGHER renewal fees will be charged for Trade Marks registrations due to expire after June 30th, 1955; and after the latter date there will be a general increase in the fees payable in respect of a number of trade marks matters. The fees have remained substantially unchanged for many years despite considerable increases in administrative costs.

Spencer-Bonecourt-Clarkson, Ltd.

BABCOCK & WILCOX, LTD., announce the fusion of the trading activities of two of their subsidiary companies, Spencer-Bonecourt, Ltd., and the Clarkson Thimble Tube Boiler Co., Ltd. The name of the former company has been changed to Spencer-Bonecourt-Clarkson, Ltd., and it has assumed responsibility for all new business in Spencer-Bonecourt waste heat boilers, the Clarkson marine and industrial waste heat, oil and gas-fired boilers, and the new Autoheat oil-fired domestic boilers.

Hungarian Aluminium Foil Plant

A NEW foil-rolling mill has begun production in the Matyas Rakosi engineering works in Budapest, which will raise Hungary's production of this product by 25% and correspondingly cut imports. Hungarian aluminium is used for the the foil, which is required for the domestic food and chemical industries.

The Iron and Steel Institute
Annual General Meeting

THE Eighty-Sixth Annual General Meeting of The Iron and Steel Institute was held on Wednesday and Thursday, 27th and 28th April, 1955, at the offices of the Institute, 4, Grosvenor Gardens, London, S.W.1.

Presentation of Awards

The Chair at the Business Meeting on the Wednesday morning was occupied by The Hon. R. G. Lyttelton, the Retiring President, who extended a welcome to members and visitors, particularly those who had come from overseas. Following the adoption of the Report of Council and the Statement of Accounts for 1954, came the presentation of medals and prizes, details of the awards being as follows.

The Bessemer Gold Medal for 1955, awarded to PROFESSOR JOHN CHIPMAN, Head of the Department of Metallurgy, Massachusetts Institute of Technology, in recognition of his distinguished contributions to the knowledge of the physical chemistry of steelmaking.

The Sir Robert Hadfield Medal for 1955, awarded to MR. TOR FJALAR HOLMBERG, of Oy Vuoksenniska A.B., in appreciation of his meritorious service in improving the technique of the production of iron and steel at the Imatra Works, Finland.

An Andrew Carnegie Silver Medal for 1954, awarded to DR. B. CINA, Brown-Firth Research Laboratories, in respect of research at Sheffield University and a paper on "The Effect of Cold Work on the Gamma-Alpha Transformation in some Fe-Ni-Cr Alloys." (*J. Iron and Steel Inst.*, vol. 177, August.)

Three Williams Prizes for 1954, of £100 each, awarded to the following :—

(i) MR. W. JACKSON, Appleby-Frodingham Steel Co., for his paper on "Use of Coke-Oven Gas and Pitch-Creosote Firing on Tilting Furnaces." (*J. Iron and Steel Inst.*, vol. 178, December.)
(ii) MR. ROBERT MCDONALD, Colvilles Ltd., for his paper on "Steelworks Waste Heat Boiler Practice." (*J. Iron and Steel Inst.*, vol. 176, January.)
(iii) MR. A. STIRLING, Stewarts and Lloyds Ltd., for his paper on "The Pelletising of Northampton Sand Ironstones by Vacuum Extrusion." (*J. Iron and Steel Inst.*, vol. 177, May.)

As PROFESSOR CHIPMAN and MR. HOLMBERG were unable to be present, the President announced that the presentations would be made at a later date, PROFESSOR CHIPMAN'S on June 1st, when he attended the Joint Metallurgical Societies Meeting in Europe, and MR. HOLMBERG'S at the Special Meeting at Scunthorpe in October.

Award of Honorary Membership

The President said he had a further announcement to make, which he was sure would receive warm and enthusiastic acclamation, namely, the nomination of an Honorary Member. Honorary Membership was one of the highest awards the Institute could make to any of its members ; there were also the Bessemer Medal and the Honorary Vice-Presidentships. The member whom they wished to honour was SIR WILLIAM LARKE, who had just celebrated his 80th birthday, and who was already an Honorary Vice-President and a Bessemer Medallist.

In 1898, Sir William joined the British Thomson-Houston Co. Ltd., as an engineer and became a member of the Institute in 1904. During World War I, his distinguished service as Director-General of War Materials was recognised by the award in quick succession of the O.B.E., C.B.E., and K.B.E. From 1922 to 1946, he was Director of the National Federation of Iron and Steel Manufacturers, and of its successor, the British Iron and Steel Federation, and Mr. Lyttelton pointed out that it was from the results of his great work in that office that the industry was benefiting to-day. He concluded : "I think you will agree that his achievements were especially great in furthering co-operation in the industry, and in raising its prestige in all eyes, both at home and abroad, and his services to iron and steel abroad have been marked as well. With all this, he is greatly esteemed and held in high affection in his own neighbourhood, together with his wife, Lady Larke, and his daughter, Miss Joyce Larke, and he is widely beloved in the iron and steel industry, for which he has done such great work. So we ask him to accept this nomination with our cordial good wishes."

Changes on Council

The Secretary announced that since the last General Meeting in November, 1954, DR. MAURICE COOK, President of the Institute of Metals, had replaced DR. S. F. DOREY and MR. T. H. ARNOLD had succeeded MR. F. H. SANITER as President of the Sheffield Metallurgical Association.

As no other nominations had been received, the following retiring officers were declared re-elected : MR. G. H. LATHAM, MR. J. SINCLAIR KERR and DR. H. H. BURTON (Vice-Presidents), and DR. J. W. JENKIN, MR. W. F. CARTWRIGHT, MR. F. H. SANITER, MR. T. JOLLY and MR. R. A. HACKING (Members of Council).

Since the last General Meeting, an Andrew Carnegie Scholarship valued at £150 had been made to A. S. APPLETON (Liverpool University) to assist research on "The Kinetics of Graphitisation in High-Carbon Fe-C and Fe-Co-C alloys, together with Subsidiary Diffusion Experiments on Fe-C-Si and the Above Alloys."

As a result of the election at the meeting of 138 new members the total membership of the Institute is now 4,872.

Induction of New President

In handing over the responsibilities of office to the new President, SIR CHARLES BRUCE-GARDNER, Mr. Lyttelton said of him that although in his early life he could have chosen the easiest way in any career, he chose industry and trained for it the hard way. He served his time as an engineer before entering the steel industry and winning his way to the top. In the two world wars his experience and advice were enlisted at national level, and he did distinguished service at the time of the first world war in financing the expansion of industry. After the war his advice was invaluable in the same field in all those problems connected with and arising out of the war.

It was this experience which formed the basis of Sir Charles' Presidential Address on "Our Industry—Decline and Recovery 1910–1933," in which he traced the vicissitudes which the industry underwent during this critical period in its history. The address, which has now been published in the May issue of the *Journal of the Iron and Steel Institute* provided a timely reminder that there was a time when record outputs were decidedly not the order of the day. As MR. JAMES MITCHELL remarked in proposing the vote of thanks to the President for his Address: "The tone was sombre, at a time when we needed it to be sombre, and the morals were drawn with an emphasis that is very much required. The audience now present consists of two parts—those who remember what the President was talking about, although all of them did not live through, as he did, all of the incidents; and those who were too young to know precisely how bad things were. It is very easy for us to-day to imagine that we can go along hopefully and just as we are."

Technical Sessions

The remainder of the meeting was devoted to technical sessions for the presentation and discussion of papers, a list of which was published on page 200 of our April, 1955 issue.

Arctic Ore Storage Plant

SOON after the war it was found necessary for the Kiruna orefields to prepare for switching over from open cast working to underground mining, so that the need for rationalisation became imperative. A thorough stocktaking of the existing facilities was made, and it was found that the ore storage and transport plant at Narvik which was built in 1902 and had undergone very little expansion since—was in need of a radical modernisation, especially so since the need for a considerably increased output was envisaged for the future. The present tendency for iron and steel works to demand better grading of phosphorus content and greater homogeneity in the different qualities of ore makes closer classification necessary, and this was a further reason for constructing a new storage and grading plant.

Under the old system the ore was delivered at Narvik in 35-ton ore wagons and was then dumped into 4-ton Norberg tipping cars and hauled by locomotive to the storage piles: reloading for crushing and shipment was effected by means of shovel cranes. Such a procedure calls for an excessive number of operations and entails much loss of time, and the new scheme, which is served by travelling loading bridges, a series of in- and out-going conveyor belts, and travelling bucket cranes, will mean a saving of time and labour, and at the same time ensure a steady inflow and outflow of ore. It entails no waiting for the crushed-ore supplies to be replenished, as two conveyor-belt systems having an identical carrying capacity of 4,000 tons/hour will be able to unload and refill the 72 ft. high ore piles at the same pace.

When the underground mining scheme has been carried through at Kiruna, the ore will arrive at Narvik already crushed to shipping size, 10 cm. Five giant boulder crushers, believed to be the largest in the world, have just been completed for the Swedish company's underground mines at Kiruna and Malmberget. They were built by Morgårdshammars Mekaniska Verkstad and are equipped with the largest SKF bearings ever mounted in a jaw crusher. In principle, no crushing will thus be necessary at the storage yards, except when, during spells of exceptional cold, the ore may freeze into big blocks, too large to be carried on the conveyor belts. A crushing plant consisting of four big crushers has been built for use in such a contingency.

The ore storage yard consists of a rectangular space, 2,600 ft. long × 330 ft. wide, divided into two parts by a steel duct carried on 23 pillars of reinforced concrete, 75 ft. high and placed 110 ft. apart. This bridge-like construction serves as a support for the pendulum end of four travelling loading platforms and four travelling bucket cranes, and it also carries two reversible 1,300 ft. conveyor belts, which serve as feeders for the storage piles. The supporting legs of the platforms and cranes are anchored in two concrete walls running the full length of either side of the storage yard. These walls also carry the 2,600 ft. long outgoing conveyor belts, which in their turn, serve a new system of belts abutting on the loading quays.

The ore wagons arriving from Kiruna—classified as to phosphorus content—are first directed to a central unloading plant, which has been blasted into the rock, and has a depth of 66 ft. and a floor area of 4,500 sq. ft. Here the crushing takes place, after which the ore is loaded on to a set of conveyor belts, which carry it to a point situated in the middle of the storage yard, whence it is distributed on to the pillar-borne feeder system. From here the ore is spread by means of the travelling unloading platforms, which are provided with special distributor belts set at right angles to the main conveyor system. The ore is thus "sifted" easily and evenly over the different piles. The 8-wheeled unloading cranes, which have a span of 170 ft., have a wheel load of 65 tons per wheel. The designing of their runway presented great difficulties, as the stress of such a heavy load demands a very sturdy structure. Thus, all foundations had to be laid on rock, as is also the case with the pillars supporting the feeder duct.

One of the most interesting aspects of the new construction scheme at Narvik is the fact that—according to the provisions laid down in the building contract—there was to be no interruption in the normal run of the loading and crushing operations while the work was in progress. The German contractors, Demag AG, of Duisburg, and the Norwegian firm of Höijer-Ellefsen, who were commissioned to carry out the mechanical work and the concrete construction, respectively, completed the modernisation stage under review in record time without causing any interruption. A second stage, smaller in scope, is expected to be completed towards the end of this year. The entire scheme when completed, will have cost in the region of £7 million.

Aluminium Imports

The Board of Trade announce that separate licences are no longer needed for the import from any source of unwrought aluminium, unwrought aluminium alloys, and aluminium scrap. Details are given in Notice to Importers No. 729 dated April 29th, 1955.

NEWS AND ANNOUNCEMENTS

U.K. Adviser for Taiwan

Mr. Robert I. L. Bell, Newport, Monmouthshire, left for Taiwan (Formosa) at the beginning of May to spend six months as a United Nations Technical Expert to advise the Taiwan Aluminium Corporation on the improvement and modernisation of its present equipment and processes. The particular fields to be studied will include process control, chemical and metallurgical smelting techniques, operations of the aluminium plant, the pot-line, and the slab-casting shop, and Mr. Bell will hold regular conferences with Chinese engineers for technical studies.

The Taiwan Aluminium Corporation is a Government enterprise at Kaohsiung, in South Taiwan. The aluminium plant consists of two alumina units each for 16,000 tons of alumina per year and a pot-line for 8,000 tons per year, as well as a sheet rolling mill, a small extrusion press and miscellaneous fabricating tools.

Mr. Bell is a Graduate Member of the Institution of Chemical Engineers and from 1950–1954 was Reduction Superintendent with the Australian Aluminium Production Commission at Melbourne, Victoria, to which the British Aluminium Co., Ltd. are technical consultants. Previously Mr. Bell was from 1946–1949 assistant manager at the Latchford Works, Warrington, of the British Aluminium Co., Ltd.

New English Steel Subsidiary

English Steel Corporation, Ltd., announce the formation of a new wholly-owned subsidiary company under the name of Davis & Lloyd (1955), Ltd., which has taken over the interests of the well-known firm of Davis & Lloyd, Ltd., of 26 Victoria Street, London, in the design and production of cast steel side frames and bolsters, cast steel unit brake beams, snubbers and other like parts and appliances for railway rolling stock.

Mr. Ernest Lloyd, for many years principal partner of Davis & Lloyd and later Chairman and Managing Director of Davis & Lloyd, Ltd., who has retired from the company, will continue to be available in a consultative capacity. Mr. F. Mason, who has been closely associated with Mr. Ernest Lloyd for many years, and who was also a Director of the old Company, becomes a Director of the new Company.

Mr. F. Pickworth, Managing Director, and Dr. C. J. Dadswell, Director, of English Steel Corporation, Ltd., become Chairman and Managing Director respectively of Davis & Lloyd (1955), Ltd., with Mr. F. S. Beale, a Director of English Steel Corporation, Ltd., also a Director of the new Company.

B.O.C. Organisational Changes

Mr. J. S. Hutchinson, Chairman of the British Oxygen Co., Ltd., referred at the Annual General Meeting on May 24th to major changes that are to take place in the structure of the company and its subsidiaries. The re-organisation plan will be put into operation as from October 1st, 1955.

A new operating subsidiary company " British Oxygen Gases, Ltd. " (authorised share capital £15 million) is to be formed to undertake all trading operations in industrial and medical gases and equipment, at present carried out by the parent concern, British Oxygen Co., Ltd. In addition, the existing Chemicals Division will be similarly formed into a new subsidiary " British Oxygen Chemicals, Ltd."

In this connection, it has been decided to appoint to the board of the parent company two new directors, Mr. T. E. Potts (at present Managing Director of African Oxygen and Acetylene (Pty.), Ltd.), and Mr. J. Strong (at present Managing Director of Quasi-Arc Co., Ltd. and Fusarc, Ltd.). Arrangements are also in hand for the grouping of B.O.C. interests in electrode manufacture and electric welding processes, including the activities at present carried out by the Quasi-Arc and Fusarc Companies.

Exhibition of European Medals, 1930-55

With the object of encouraging public interest in medallic art, the Royal Society of Arts, with the collaboration of the Royal Numismatic Society and the Fédération Internationale des Editeurs de Médailles (F.I.D.E.M.), is holding an Exhibition of European Medals, covering the period from 1930 to 1955, at its House in John Adam Street, Adelphi, London, from Thursday, June 9th to Wednesday, June 29th.

The Exhibition, which is the first of its kind ever to be so organised in Great Britain, will contain over 200 medals, representing the finest work of leading designers from 13 European countries—Austria, Belgium, Denmark, Finland, France, Great Britain, Holland, Italy, Norway, Portugal, Spain, Sweden and Switzerland. In addition to a small number of coins, the exhibits will include an impression from the silver dies of the new Great Seal of England, shown by special permission of H.M. The Queen, specimen Royal Tour Medals of 1953, a case of Coronation Medals from the time of King Edward VI, specially prepared for the Exhibition by the Royal Mint, and an exhibit illustrating the technical processes of medal production provided by the Director of the Paris Mint.

Admission to the Exhibition will be free, and the hours of opening will be from 10 a.m. to 5-30 p.m. on weekdays and Saturdays (Wednesdays to 7 p.m.).

Sir William Larke

The Institute of Welding and the British Welding Research Association held a Luncheon at the Hyde Park Hotel on Monday, April 25th, to celebrate the eightieth birthday of Sir William J. Larke, K.B.E. Sir Claude Gibb, C.B.E., F.R.S., was in the Chair, supported by the President of the Institute, Mr. R. G. Braithwaite, and the Chairman of Council of the British Welding Research Association, Sir Charles Lillicrap, K.C.B., M.B.E.

Mr. Braithwaite presented to Sir William the certificate of his Honorary Fellowship of the Institute of Welding and Sir Charles Lillicrap presented an illuminated address on behalf of the Institute and the British Welding Research Association. The toast of Sir William Larke's health was proposed by Sir Claude Gibb, the Chairman.

Among those present were Mr. and Mrs. W. M. Larke, Miss J. Larke, Lady Lillicrap, Mrs. Braithwaite, Sir Charles Bruce-Gardner, Sir Roger Duncalfe, Sir Charles Goodeve, Sir Ernest Smith, Dr. Howard Biers, Major J. Caldwell, Mr. A. Clifford Hartley, Mr. K. Headlam-Morley, Mr. A. Robert Jenkins, The Hon R. G. Lyttelton, Mr. W. W. Watt and Professor G. Wesley-Austin.

Araldite Price Reductions

AERO RESEARCH, LTD., Duxford, makers of Araldite epoxy resins, state that greatly increased output of these products has made it possible to reduce manufacturing costs, and with them the prices at which Araldite can be purchased.

Personal News

A NEW Electronics Department formed at Metropolitan-Vickers Electrical Co., Ltd., incorporates the present Radio Department, part of Marine and Special Contracts Department, and the service electronics section of Industrial Electronic Control Engineering Department. The industrial section of Industrial Electronic Control Engineering Department has been re-named Industrial Process Control Engineering Department. The following officials of the Electronics Department have been appointed: Superintendent—MR. E. T. W. BARNES (formerly Superintendent, Radio Department); Assistant Superintendent—MR. D. E. THORNHILL; Chief Engineer—Dr. L. W. BROWN (formerly Chief Engineer, Radio Department); Assistant Chief Engineer—MR. T. R. GOODE (formerly Assistant Chief Engineer, Radio Department); Assistant Chief Engineer (Special Applications)—MR. J. L. RUSSELL; Sales Manager—MR. L. H. J. PHILLIPS (formerly Sales Manager, Radio Department); Assistant Sales Manager—MR. J. NICHOLSON (formerly Assistant Manager, Marine and Special Contracts Department) MR. G. W. G. CANTER, formerly Manager, Marine and Special Contracts Department, has been appointed Manager, Special Contracts and will be located in London.

FOLLOWING the resignation of MR. J. R. FERGUSON from the Crompton Parkinson, Ltd., associate Company, Cooke & Ferguson, Ltd., the appointment is announced of MR. A. F. KISTNER as General Manager of the Cooke & Ferguson Switchgear Works in Manchester.

SIR IVAN STEDEFORD, K.B.E., Chairman of Tube Investments, Ltd., left by air for Canada on the 17th of May, to visit Montreal, Toronto, London and New York, and also the associate Company, Standard Tube and T.I., Ltd., at Woodstock, Ontario.

MR. R. J. DIXON, Chief Engineer of Wickman, Ltd., has been appointed a Director of the Company. He was appointed a Special Director in 1953.

MR. F. P. DYSON, Director in Charge of Construction in the Woodall-Duckham Construction Co., Ltd., has been appointed a Director of the Parent Company, Woodall-Duckham, Ltd.

DR. F. P. BOWDEN, F.R.S., of the University of Cambridge, has been appointed Chief Research Consultant and in charge of the Tube Investments Research Laboratories at Hinxton Hall, Cambridge. The laboratories are undertaking fundamental research in physics, chemistry, metallurgy, engineering, electronics and related sciences, and the following have been appointed Research Scientists: A. CHARLESBY, J. E. GORDON, A. P. GREEN, R. J. W. MCLAUGHLIN, J. W. MENTER, D. W. PASHLEY, G. W. ROWE and R. WORRALL.

AT the Tenth Annual General Meeting of the Federation of Light Metal Smelters, MR. O. G. HALLIWELL, was re-appointed Chairman for the current year and MR. B. ENDLAR was appointed Vice-Chairman.

BRITISH INSULATED CALLENDER'S CABLES, LTD., announce that MR. H. THOMSON has been appointed their Branch Manager, Glasgow.

AT the Annual Meeting of The International Nickel Company of Canada, Ltd., the following retiring Directors were re-elected: EDWIN G. BAKER; LEWIS W. DOUGLAS; J. ROY GORDON; H. R. MACMILLAN, C.B.E.; THE RT. HON. VISCOUNT MARGESSON, P.C., M.C.; R. SAMUEL MCLAUGHLIN; H. C. F. MOCKRIDGE, Q.C.; THEODORE C. MONTAGUE; R. L. PRAIN, O.B.E.; GEORGE C. SHARP; JOHN F. THOMPSON; and THE RT. HON. VISCOUNT WEIR, P.C., G.C.B. At a subsequent meeting of the Board, MR. R. W. PARKER of Copper Cliff, Ontario, was elected Vice-President and MR. W. A. MCCADDEN, Comptroller.

CONSEQUENT upon the inauguration of the Metropolitan-Vickers X-Ray Department, which took over the business of M-V's subsidiary, Newton Victor, Ltd., at the beginning of the year, the branch offices of Newton Victor were amalgamated with the district offices of Metropolitan-Vickers. MR. H. B. GOUGH is Sales Manager, X-Ray Department, and MESSRS. G. E. H. DEADMAN (Birmingham), R. B. GOUGH (London), A. R. HOLDSWORTH (Sheffield), D. MOODIE (Glasgow), H. A. RYDER (Cardiff) and J. TAYLOR (Manchester) are Superintendents, Newton Victor Sales, in the districts stated. MR. A. K. NUTTALL is Chief Engineer, X-Ray Department, and Mr. F. W. WATERTON, Assistant Chief Engineer, X-Ray Department, Finchley Works. MR. J. T. THORNHILL is Works Manager, Motherwell and Finchley Works.

MR. D. BRYARS has been appointed to the Board of Directors of The Sheffield Smelting Co., Ltd., with special responsibilities in the field of Sales Control. MR. R. R. ELLERBY, Secretary, has been appointed a Special Director.

MR. D. R. S. TURNER has been appointed Manager of the Larne (N. Ireland) Works of The British Thomson-Houston Co., Ltd., which, when completed, will be devoted to the manufacture of the largest steam turbines and turbo-generators of 30 MV upwards, and to blading manufacture for Larne and Rugby.

MR. W. CLIFFORD ATKINS has been appointed a Director of the Aston Chain & Hook Co., Ltd., non-ferrous metal engineers, of Erdington, Birmingham.

Obituary

WE regret to record the death of the following:

MR. R. T. PRIESTMAN, Managing Director of T. J. Priestman, Ltd., Birmingham, who died on May 2nd, after a short illness.

MR. R. J. PARKER, who died on May 1st. Mr. Parker held many important positions in the firm during his 48 years connection with George Kent, Ltd. In recent years he was Manager of Spares and Repairs Department.

RECENT DEVELOPMENTS

MATERIALS : PROCESSES : EQUIPMENT

Stud/Arc Welding Power Unit

NEWLY introduced by the Crompton Parkinson Stud Welding Organisation is a transformer-rectifier unit that has been specially developed to meet the requirements of both stud welding and manual arc welding. The unit provides a choice of three outputs—one for stud welding up to ½ in. diameter studs ; another for single operator arc welding with current up to 400 amps ; and a third for two independent arc welding operators using up to 200 amps each. As a new power source, it therefore fulfils a long felt need, particularly so in that selection of output is rapidly accomplished by means of a three position switch, and in that facilities are provided for independent remote control of arc welding currents. Hitherto it has been necessary either to employ separate power sources for stud welding and arc welding, or to make cumbersome adaptations to stud welding power sources so that they could be employed to a limited extent for arc welding. Similarly, arc welding generators can be used only for a limited range of stud welding applications.

The new power source consists basically of a 3-phase air-cooled transformer which is suitable for input voltages of 210/250 and 360/440 and for operation on a 40/100 cycle supply ; two banks of selenium rectifiers which can be operated either in parallel or independently, according to the position of the selector switch ; and two magnetic amplifiers which facilitate fine control of current when the equipment is used for arc welding. This latter feature, in conjunction with two continuously variable rheostats connected by 20 ft. of cable, enables the operator to make accurate adjustment of the current at the point of welding.

The rectifier, transformer and other internal components are maintained at a safe operating temperature by means of a totally-enclosed fan. Incorporated with the fan is a centrifugally operated switch which, if the motor ceases to operate for any reason, automatically interrupts the exciter supply thereby reducing the output to a safe level. Other important features include the so called " hot start ", i.e.. a 25% current increase which occurs momentarily at the commencement of arc welding and provides for easy striking of the arc, and the fact that the unit is a non-inductive power source, with the result that its current recovery time is comparable with that of an arc welding transformer.

Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2.

Power Oscillator

THE Model D120 power oscillator which provides a power output of 120 watts over a wide frequency range has been designed for use with the Goodmans vibration generator, Model 390 A, where appreciable power is required for forced vibration excitation. The unit is a complete drive equipment consisting of an oscillator and power amplifier with its associated power supplies contained in a mobile console cabinet.

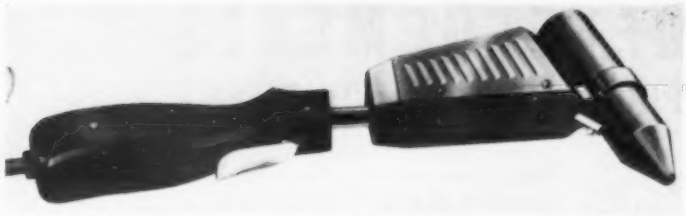
The oscillator is a resistance-capacity coupled two stage circuit employing automatic amplitude control by means of a thermistor in a feedback loop. Tuning is effected by a continuously variable double potentiometer in conjunction with a range switch selecting appropriate values of fixed capacity. Calibration adjustment is effected by pre-set potentiometers. All controls are grouped at a convenient height on the sloping control panel.

The drive to the amplifier is taken from a continuously variable potentiometer across the oscillator output, and this acts as a gain control. One half of a double triode valve operates as an amplifier and this feeds into the second half of the same valve, which operates as a phase-splitter driving a parallel push-pull output stage. Overall feedback is applied from the secondary of the output transformer to the cathode of the first amplifier stage.

The main body of the console houses the power supplies and power amplifier together with the special output transformer. Connections for the mains supply and the amplifier output are at the base of the rear panel, which can be removed to gain access to components and wiring. The valves and valve current metering socket can be reached by removing the front panel on the main console. A thermocouple ammeter mounted on the control panel indicates the current fed to the moving coil of the vibration generator.

The frequency range is 10 to 10,000 c./s. in three ranges ; calibration accuracy is ± 2% ; hum level is —70 db.; and distortion is less than 2%. Power supply is a multi-tapped mains transformer for 100/120 V., 200/250 V., 50/60 c./s., 700 VA.

Goodmans Industries, Ltd., Axiom Works, Wembley, Middlesex.



Aluminium Soldering Tool

THE difficulties associated with the soft soldering of aluminium alloys have their origin in the tenacious oxide film on the surface of the metal, and it is essential that no oxidation takes place between cleaning and tinning. Soldering with flux presents many difficulties, not least being the corrosive action of residual flux, and recent developments in fluxless soldering include the ultrasonic method. A fluxless process which has been used for some time is friction soldering, which, being manually performed with a sharp tool or wire brush, is slow and somewhat tedious. The Belark electric soldering tool has turned this method into a fast, reliable process, capable of being performed by unskilled labour. A small steel wire brush located in the solder bit vibrates and cleans the surface by mechanical means. A pool of molten solder around the solder bit protects the spot from air, and as soon as the oxide film is broken up, the molten solder tins the surface. Jointing is then carried out as in normal soldering.

The front part of the tool consists of a copper rod with a copper bit attached to one side, and a heating element of 165 watts to the other. From the centre of this copper core extends a steel bracket which carries the vibrator and the junction box. The end of the bracket is fixed to the bakelite handle. A small steel wire brush is located in the centre bore of the solder bit and is connected to the vibrator arm by a steel rod, The vibrator has a frequency of 100 c./s., and is pivoted at one point with a spring-support on one side and an adjustable screw on the other. The spring serves to compensate for thermal expansion, and the screw with a locking device to bring the brush into the right position. The heating element is directly connected to the mains, and the vibrator lies in a switch circuit controlled by a trigger. The steel-encased heating element is built as a hollow cylinder and is lined inside with a slotted copper sleeve ; it fits closely round the copper core in order to increase the contact area, and to ensure the best possible heat conductivity to the solder bit. Both heating element and vibrator are covered by hoods, and all metal parts are chromium-plated to protect them from corrosion. The well-shaped handle houses the trigger switch and the terminals for the cable.

The Belark Tool Stamping Co., Ltd., 33 *Sussex Place, London, W.2.*

Portable Grinders for Depressed Centre Grinding Discs

UNTIL recently it has only been possible to use centre reinforced grinding disc wheels on sanders, machines which do not possess the power and speed requisite for their correct use. The Wolf research and design department has developed two new machines—the portable electric high speed heavy duty Angle Grinders,

Types AG7 and AG9. This has involved the design of an entirely new universal type motor which is continuously rated at 1·5 b.h.p., as only thus is it possible to provide the 8,000 and 6,000 r.p.m. required for obtaining maximum performance and disc life with the 7 in. and 9 in. discs, respectively.

In terms of stock removal, the performance of these machines must vary considerably in the angle of operation, etc., but it is claimed that their minimum performance is at least 100% better than the most powerful universal sander fitted with depressed centre grinding discs. Grinding is done with the edge of the disc, and both models accommodate discs from $\frac{3}{16}$ in. to $\frac{3}{8}$ in. thick, although those supplied as standard equipment are $\frac{1}{4}$ in. thick.

The AG7 and AG9 Angle Grinders fitted with resin-bonded cut-off wheels provide an ideal, easy, convenient and fast method of cutting bar stock steel angle lengths in metal stores or on site, and of cutting off risers, runners and gates in the foundry. Only two types of cut-off disc wheels are necessary ; one for ferrous and non-ferrous metal and the other for cutting stone. Specially designed high speed backing pads with a wide range of silicon carbide and aluminium oxide fibre backed sanding discs are also available as accessories.

Wolf Electric Tools, Ltd., Hanger Lane, London, W.5.

Low Temperature Paint

IT is claimed that Pitan Cold Temperature Resistant Paint, developed by Allweather Paints, Ltd., the chlorinated rubber paint specialists, will withstand temperatures as low as—60° F., and yet remain flexible. It incorporates a special cold temperature resistant plasticiser, and provides a surface which withstands acid and alkali attack, and the destructive effects of lime and ammonia.

Allweather Paints Ltd., 36 *Great Queen Street, London, W.C.2.*

CURRENT LITERATURE

Book Notices

THE PREVENTION OF CORROSION

20 pp., 2 illustrations. London, 1955. The British Iron and Steel Research Association, 11, Park Lane, W.1. 2s.

THE results of prolonged investigation into the causes and inhibition of corrosion are dealt with in this booklet, where the subject is discussed under three main headings, corrosion in air, water, and soil.

In dealing with structural steels, the importance of good basic design is stressed. Apart from avoiding opportunities for the lodgement of moisture and atmospheric grime, sound design acts as an important inhibiting agent by encouraging efficient maintenance. After a consideration of the virtues of rust-resisting steels, the conclusion is reached that for economic reasons low-alloy steels offer the best inherent qualities for general use as structural materials. As regards the protective painting of steel, the important factors are thorough surface preparation, the use of a suitable inhibitive priming paint, and adequate thickness of the complete painting scheme with finishing coat.

Corrosion in water is treated from two aspects—ship structure and shore installations. Details are given of the performance of anti-corrosive composition No. 185. Severe and prolonged service tests show that this formula is particularly long-lasting, and can be easily maintained in service. The value of metal coating and cathodic protection are also considered.

Corrosion in soil is treated with special reference to graphitisation, arising from anaerobic environment in heavy soils. Differences in protective coatings are discussed in detail, with special reference to blown bitumen as inhibiting agent.

R.F. INDUCTION HEATING HANDBOOK

32 pp., numerous illustrations. Radio Heaters, Ltd., Wokingham, Berks. 6s.

RADIO frequency induction heating offers many advantages where certain types of heat treatment, soldering and brazing are called for in mass production work. The cleanliness, coolness and compactness of the technique enables it to be used directly in the production line, just as a machine tool would be. Furthermore, provided, the heating coil and work-holding jig are well designed, uniform results can be obtained without skilled labour. The method is particularly suited for those components where localised heating is required.

The purpose of this profusely illustrated brochure is to show manufacturers who do not know of, or fully appreciate, the use of induction heating, the advantages to be gained by this process; and those manufacturers now using induction heating many different applications of which they may not be aware. In addition to more than a hundred photographs and diagrams of various applications, there are graphs from which capital and running costs may be estimated

The various sections of the brochure deal with such topics as, the way in which induction heating works, costs, induction hardening, soldering and brazing, through heating, annealing, heating carbon, eddy current heaters for vacuum tubes, semi-conductor production and zone refining, dielectric heating, and avoiding interference.

THE NON-FERROUS METALS INDUSTRY IN EUROPE

A Report by the Non-Ferrous Metals Committee of O.E.E.C.

THIS report deals with the economic situation in the European non-ferrous metals industry during 1953 and the first half of 1954, and contains a series of detailed studies of market trends for each metal.

The Committee lays the main emphasis on the question of prices, dealing both with present levels and past fluctuations. Attention is drawn to the need for greater price stability, and the Committee may consider ways and means of preventing excessive price fluctuations.

The report also deals with the influence of non-commercial factors on markets, with special reference to the U.S. stockpiling policy, which is bound to have repercussions in Europe, owing to the fact that non-ferrous metals constitute a world market.

After a brief reference to the main features of the period 1950–52, short and long term trends of production, consumption and prices are reviewed. An annex to the report gives detailed production and consumption statistics for member countries and overseas territories, together with figures showing the proportion of imports in the total supplies of the O.E.E.C. area during the last few years.

MACHINING ALUMINIUM

Revised Edition of No. 7 in the series of Information Bulletins published by The Aluminium Development Association, 33, Grosvenor Street, London, W.1. 56 pp., numerous illustrations and tables. 2s.

In this revised edition of a Bulletin first published in 1944 under the title of "Machining of Wrought Aluminium Alloys," the word aluminium is used to cover the alloys as well as the metal itself, unless it is qualified as pure. In the course of revision, data on the machining of cast alloys have been added, and the scope of the Bulletin now covers workshop practice in the extended range of industries which have adopted aluminium since the Bulletin first appeared.

It is a major difficulty in dealing with this subject, for any metal, that day to day practice is bound up with many factors that can be determined only by trial and error. This point is made clear in the present publication, and the data presented are the outcome of experience and tests over a long period by a manufacturer specialising in machining research. The investigators aimed at allowing for every variation that practical experience suggests—including tool life—so that the results (though sometimes conservative) give comparable data covering all the standard aluminium alloys and all the regular machining operations. The data and recommendations apply as a whole to the machines used in ordinary engineering workshop practice. A brief note is included on the very high speed machines which have yet to make their mark on general practice, but for

which it is already clear the grouping of alloys in relation to machining speeds must be modified.

The book opens with an outline of the machining characteristics of aluminium followed by an alloy group classification based on the experience and tests already mentioned. There then follow sections dealing with machines (very briefly) and, to greater extent, tool materials, cutting compounds and lubricants, and tool design. The major portion of the book covers the normal operations of turning, boring, parting, etc., accompanied in every case by recommendations on speeds, feeds and tool angles as applicable.

There is a brief discussion on the common causes of distortion during machining, and the precautions applicable to aluminium, and appendices include a list of alloys to B.S.1470/77 and 1490 with related B.S. and D.T.D. aircraft specification numbers.

Illustrations include diagrams showing the principal rake systems for comparison against that of B.S.1886 (adopted in this Bulletin) and photographs of basic chip types produced from selected cast and wrought aluminium alloys.

Trade Publications

SOME industries can reduce atmospheric pollution and fuel cost by improved combustion methods, but in many industries the pollution occurs inside the factory or plant during the industrial process. In a pamphlet received from The Power-Gas Corporation, Ltd., Stockton-on-Tees, is described the Favorit filter process, which has been successfully used for the recovery of dust and fume in such industrial processes as non-ferrous smelting and refining, crushing, grinding, screening and milling operations, the manufacture of chemical powders and paint powders, and in drying operations.

A NEW booklet has been published by R. & J. Beck, Ltd., dealing with their No. 50 universal microscope, which has been designed to meet the need for the use of the great advances which have been made in recent years in high power microscopic techniques. Provision is made for both transparent and incident illumination by light-field, dark-field, phase-contrast and polarised light methods. No provision is made for microscopic work below magnifications of $\times 12$, as the requirements are so specialised: alternative equipment is available for this class of work.

ALUMINIUM (CANADA), LTD., have had reprinted from *The Canadian Geographical Magazine* an article on the Kemano-Kitimat project of the Aluminium Company of Canada entitled "Kitimat—A Saga of Canada." It presents a most interesting account of the work of construction, which involved five separate engineering feats: constructing a dam to impound the waters of a chain of lakes; driving a tunnel through the mountain barricade to give passage to the falling waters; carving a powerhouse inside a mountain; erecting a transmission line; and building a smelter.

THE rapid expansion of the steel industry in recent years and the introduction of larger furnaces and heavier rolling mills have necessitated increased attention to the problems of fume removal and the maintenance of reasonable temperatures in the works. Modern methods of fume extraction and industrial ventilation have successfully dealt with these problems and, by creating better working conditions, made a substantial contribution to increased efficiency. The Visco Engineering Co., Ltd., have recently issued a 16-page booklet dealing with ventilating, air conditioning and fume removal in steelworks, and typical examples are given of installations in connection with rolling mills, and arc furnaces, together with particulars of general steelworks ventilation. A particularly interesting section deals with the air conditioning of crane cabs.

A PUBLICATION of more than usual significance has recently been issued by Imperial Chemical Industries, Ltd., with the title of "Wrought Titanium." I.C.I. have pioneered the production of metallic titanium in this country, the metallic titanium being produced by the General Chemicals Division, using the sodium reduction method. Melting and fabrication into wrought forms is the responsibility of the Metals Division. Titanium is commercially a very new metal with certain very desirable properties; like any other material, however, it has its limitations, some of which may disappear as fundamental and practical knowledge on the subject accumulates. The present publication is a preliminary exposition on the properties and availability of I.C.I. titanium and, in the present state of knowledge, inevitably incomplete; further editions contemplated from time to time will take account of new developments, and keep the information on the subject as up to date as possible.

AT a time when the total number of fires occurring has doubled since 1937, and the direct financial losses sustained annually exceed £26 million, the importance of adequate fire fighting equipment cannot be stressed too much. In the first issue of "Nu-Swift Fire Fighting News," the terrible consequences of outbreaks of fire are forcefully set out in word and picture, and the importance of the action taken in the first five minutes is emphasised.

BESIDES its activities in the furnace field, The Incandescent Heat Co., Ltd., manufactures a large range of foundry equipment, including cupolas, mechanical charging equipment, ladles, runways, electric furnaces, crucible furnaces, rotary sand dryers, mould drying stoves, core stoves, ladle preheaters, sand handling plant, and dust removal and collection plant. By arrangement with the Whiting Corporation of America, the complete Whiting range is included. Incandescent have recently issued leaflet V 9A, dealing with foundry plant, to replace V9.

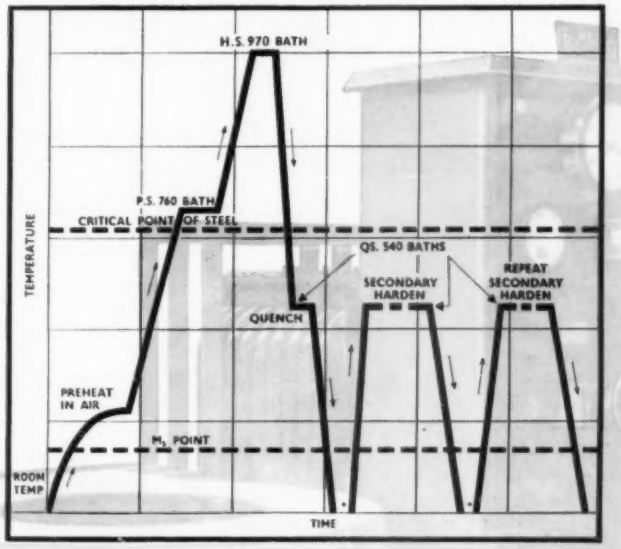
Books Received

"Sonics"—Techniques for the Use of Sound and Ultrasound in Engineering and Science. By Theodor F. Hueter and Richard H. Bolt. 456 pp. inc. author and subject indexes and numerous illustrations. New York and London, 1955. John Wiley & Sons, Inc., and Chapman & Hall, Ltd. 80s. net.

"Chemical Process Principles": Part I "Material and Energy Balances." By Olaf A. Hougen, Kenneth M. Watson and Roland A. Ragatz. Second Edition. 504 pp. and appendix and author and subject indexes. New York and London, 1955. John Wiley & Sons, Inc., and Chapman & Hall, Ltd. 68s. net.

for heat-treatment casehardening brazing . . .

The 'Cassel' Heat-Treatment Service offers a complete range of salts, furnaces and technical advisory facilities to meet all problems. Take the hardening of high-speed and hot-die steels for example—the 'Cassel' Process is widely used for treating all types of tool, from small drills to cutters weighing more than 100 lb.



Schematic representation of heating, cooling and secondary hardening cycles when hardening high-speed steel in salt baths.

The 'Cassel' Process offers these advantages:

* **Freedom from scale**
* **Elimination of decarburisation**
* **Reduced risk of cracking and distortion**
* **Accurate control of temperature**
* **Consistently high hardnesses**
* **High rate of output**

. . . consult the 'Cassel' heat-treatment service

IMPERIAL CHEMICAL INDUSTRIES LTD.
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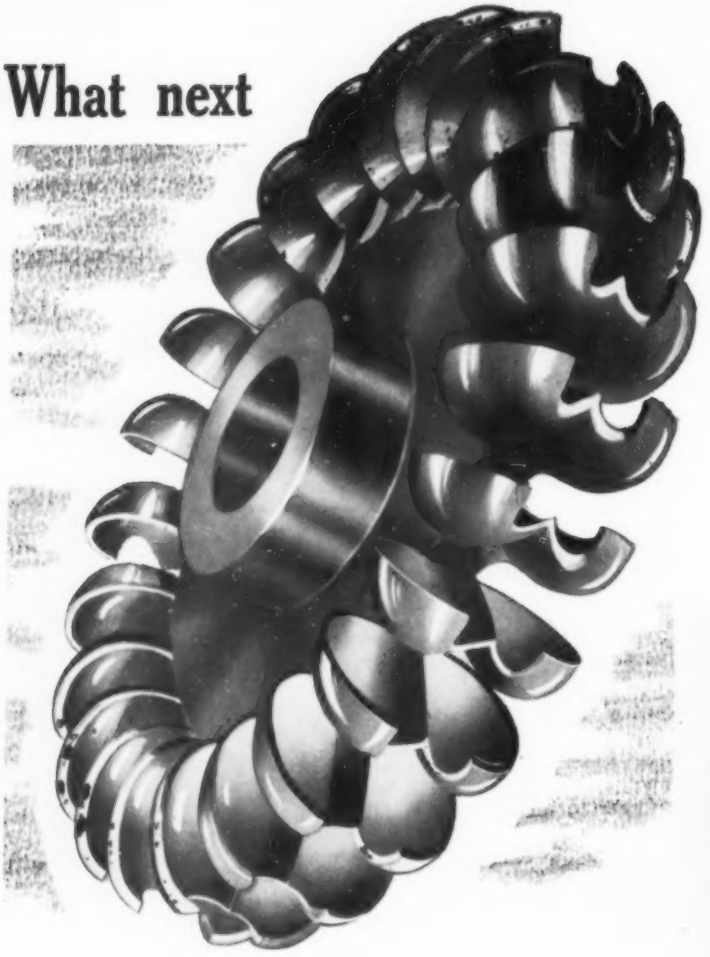
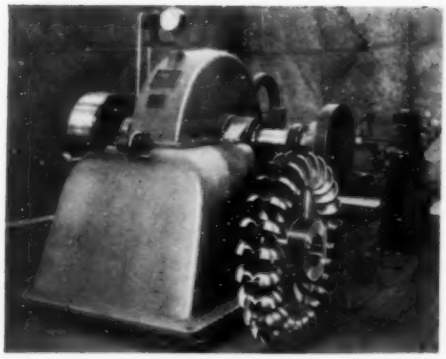
What next . . . in NON-FERROUS CASTINGS?



Casting this water turbine runner wheel in a single piece from aluminium-bronze was a considerable achievement.

Birkett, Billington & Newton were able to tackle the job because they have specialised in the development of this metal, and their unrivalled experience and facilities enable them to carry out such problematic non-ferrous castings.

Aluminium-bronze has a high yield point and a low weight/strength ratio, and is very resistant to shock, erosion, corrosion and abrasion.



The runner and other castings have been made by Birkett, Billington and Newton for this 750-h.p. Pelton Wheel Generator supplied to the New Zealand Government by Gilbert Gilkes and Gordon, Ltd., of Kendal.

Castings from a few ounces to 10 tons in phosphor-bronze, gun-metal, aluminium-bronze, manganese-bronze and light alloys. Precision-machined bushes and bearings. Specialists in high-tensile aluminium-bronze castings, centrifugal-cast wheel blanks, and chill-cast rods and tubes.

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LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

JUNE, 1955 Vol. LI, No. 308

The Photometric Determination of Iron in Aluminium Alloys

By H. Jackson, R. E. Bailey and L. H. Williams

Research Laboratories, The British Aluminium Company, Ltd., Chalfont Park, Gerrards Cross, Bucks.

A photometric method is described for the determination of iron in aluminium alloys using o-phenanthroline. The method is applicable to the determination of iron in pure aluminium and all types of alloys, and is free from interference from any of the usual alloying constituents. It can also be used for the analysis of hardeners.

THE photometric determination of iron has been the subject of a considerable number of papers in the past few years, the three main reagents used being ammonium or potassium thiocyanate, thioglycollic acid and *o*-phenanthroline. Thiocyanate has been the most widely studied reagent in the analysis of aluminium alloys.[1, 2] It is well known that the red ferric thiocyanate colour is very susceptible to variations in acidity, reagent concentration and temperature,[3, 4] which must, therefore, be rigorously controlled. Moreover, a well defined colour maximum is not attained under the operating conditions permissible in analytical determinations. In spite of these drawbacks, the reagent has given good service under routine conditions in our laboratories for many years.

We have found that *o*-phenanthroline has distinct advantages over thiocyanate; the orange-red ferrous *o*-phenanthroline complex formed in an acid buffered solution is very stable and is unaffected by wide variations in reagent concentration.

Experimental

I—Development of the Ferrous *o*-Phenanthroline Colour

Iron is reduced in acid solution with hydroxylamine, the solution is buffered with sodium acetate-acetic acid and the orange-red ferrous *o*-phenanthroline complex is developed by the addition of excess *o*-phenanthroline.[5] The transmission curve of an aqueous solution of the ferrous complex measured on the Unicam S.P. 600 spectrophotometer showed a maximum absorption at 510 mμ. Suitable filters for use with a Spekker absorptiometer were Ilford 603 with a Chance ON13 or ON20 heat filter. A range of 0–0·15 mg. iron in a final volume of 100 ml. was covered, using 4 cm. cells. This represented 0–1·2% on the sample weight of 12·5 mg. used in the method given below.

Complete and immediate reduction of iron was obtained with 2 ml. of a 1% solution of hydroxylamine hydrochloride. Up to at least 10 ml. of this reagent were without effect on the colour of the complex; 5 ml. were taken as an optimum amount.

The colour development was not complete until the *p*H of an acid solution reached 2·5. At this value the colour developed immediately and was unaffected by further increase in *p*H. In solutions containing aluminium the maximum *p*H permissible without precipitation of aluminium hydroxide is approximately 4. The use of a sodium acetate-acetic acid buffer ensured that this figure was not exceeded, the *p*H being 3–3·5 under normal conditions.

To cover the range 0–0·15 mg. iron, 5 ml. *o*-phenanthroline solution (0·15%) were found to be sufficient to give full colour development, except in special cases which are discussed in Section II. Increased amounts of reagent were without effect.

The order of addition of the reagents was not critical and the three solutions, namely, hydroxylamine, buffer and *o*-phenanthroline were combined into a single reagent solution which was stable for at least one month.

The ferrous complex was stable for at least 24 hours and was unaffected by light, or by normal variations in room temperature.

II—Interfering Elements

Amounts of copper greater than 10 p.p.m. are said to interfere with the colour developments.[5] Zinc and nickel form colourless complexes which consume *o*-phenanthroline. Other alloying elements normally found in aluminium alloys do not interefere. Experiments showed that the following amounts of copper, zinc and nickel could be tolerated under the conditions described in Section I.

		Equivalent on 12·5 mg. sample
Copper	1 mg.	8%
Zinc	2 mg.	16%
Nickel	0·5 mg.	4%

(Higher percentages of nickel were not tested).

In the case of copper, the maximum amount remaining in solution after the attack (see Section III) was equivalent to less than 8% for an alloy containing about 14%, and much less for alloys with lower copper contents. The results are given in Table I.

Greater amounts of copper, zinc or nickel were found to consume the reagent, but extra *o*-phenanthroline gave full colour development without interference. Combinations of these elements such as occur in current alloys

TABLE I.—DETERMINATION OF COPPER IN SOLUTION

Alloy	Copper Content %	Copper in Filtrate %
LM-1	6·86	4·5
LM-3	3·25	2·4
LM-12	7·6	2·5
LM-12	9·6	4·8
LM-12	11·8	5·3
LM-12	13·7	7·6
D.T.D.424A	3·60	1·8
2L35	4·35	2·7

do not interfere, and 5 ml. *o*-phenanthroline reagent are sufficient. The only special cases to consider are those of hardener alloys. Copper hardeners (50% copper) behave rather differently from alloys, and a relatively small amount of copper dissolves, though an extra 5 ml. *o*-phenanthroline solution are added as a precaution. Nickel hardeners (20% nickel) require additional *o*-phenanthroline to allow for the formation of the colourless nickel complex. 5 ml. extra reagent are sufficient to give complete colour development of the ferrous complex.

III—Preparation of Sample Solutions

In the A.S.T.M. method[6] for the determination of iron using *o*-phenanthroline, " test lead " is used to precipitate copper from solution. To eliminate this step, preliminary experiments were made using a hydrochloric acid attack, thereby largely preventing the initial dissolution of copper. By this method the amount of copper dissolved was small and did not cause interference. The iron remaining in the residue was generally less than 0·01%, although greater losses of iron did occur with some copper-zinc alloys. In addition, high silicon alloys, particularly of the unmodified type, gave cloudy solutions which were difficult to filter.

A caustic soda attack followed by acidification with hydrochloric acid overcame these difficulties, the high silicon alloys being oxidised by a modification of the ALAR method [2] (page 71) which ensured clear solutions. The amounts of copper dissolved by this technique, though greater than by direct acid attack, were still low enough not to interfere, and are shown in Table I.

The undissolved residues from a whole range of alloys were examined for iron but the amounts present were insignificant.

Results

A range of alloys and hardeners was analysed by the method given below, and typical results are given in Table II. The standard deviation was ± 0·014%, calculated on 44 results from a range of alloys, and ± 0·016% on 365 results from two daily determinations on 2L35 and LM-12 samples containing 0·38% and 0·74% iron respectively.

Method

Reagents

Hydrochloric Acid—A.R. quality.

Sodium Hydroxide—20% solution.

Standard Iron Solution—Dissolve 0·2007 g. standard steel (99·64% iron) in 20 ml. sulphuric acid (1 : 3), cool, and dilute to 1,000 ml. Dilute this solution 20-fold to give a solution 1 ml. = 0·01 mg. iron.

Mixed Reagent—

(1) Hydroxylamine hydrochloride, 1% solution.

(2) *o*-Phenanthroline monohydrate, 0·15% solution in water. Warm to dissolve.

(3) Acetate buffer. Dissolve 272 g. sodium acetate ($CH_3 \cdot COONa, 3H_2O$) in 500 ml. water, filter, add 240 ml. acetic acid (glacial) and dilute to 1,000 ml.

Prepare the mixed reagent by mixing the above three reagents in the proportions 1 : 1 : 3.

Procedure

Treat 0·1 g. millings with 10 ml. sodium hydroxide solution (20%). When the attack is complete, wash down and boil gently for 2–3 minutes. For high silicon alloys (silicon > 4%), stand the beaker on the edge of the hotplate for 20 minutes at a temperature just below boiling point, to oxidise the silicon, before boiling (see Note 1). Wash down, dilute to approximately 25 ml., add 15 ml. hydrochloric acid, mix and boil gently for 10 minutes. Cool, filter through a Whatman No. 4 filter paper into a 200 ml. graduated flask, dilute to volume and mix well.

Pipette a 25 ml. aliquot (see Note 2) into a 100 ml. graduated flask, add 25 ml. mixed reagent (see Note 3), dilute to 100 ml. and mix well. Measure the extinction on the Spekker absorptiometer, using the mercury lamp and Ilford 603 and Chance ON 13 (or ON 20) filters with 4 cm. cells. Carry out a blank determination on the reagents and pipette the same aliquot as taken for the sample.

Calibrate the Spekker as follows: pipette aliquots of standard iron solution (1 ml. = 0·01 mg. iron) up to 15 ml. into a series of 100 ml. graduated flasks. Dilute, add 25 ml. mixed reagent, dilute to volume, and measure extinctions as described for the samples. A plot of extinctions against the nominal iron contents gives a straight line.

TABLE II

Alloy	Ref. No.	Composition %						% Fe by Volumetric Method	% Fe by *o*-Phenanthroline Method
		Si	Cu	Zn	Ni	Mn	Mg		
LM-1	81752	2·75	6·85	2·70	0·20	0·52	0·09	0·60	0·59, 0·60
LM-3	81758	0·84	3·25	11·25	0·31	0·41	0·11	0·63	0·65, 0·63
LM-7	82068	2·45	1·33	0·07	1·05	0·07	0·15	1·01	1·02, 1·03
LM-12	81760	0·33	7·6	0·02	0·05	0·20	0·16	0·78	0·78, 0·77
LM-12	81761	0·50	9·6	0·07	0·15	0·40	0·28	0·61	0·60, 0·61
LM-12	81762	0·74	11·8	0·15	0·30	0·63	0·48	0·34	0·33, 0·34
LM-12	10	0·55	13·74	1·03	0·03	0·56	0·77	0·45	0·45, 0·45
LM-12	10L	2·77	7·13	0·10	0·60	0·19	0·04	1·24	1·24, 1·26
2L35	8374/6	0·51	4·35	0·07	2·14	0·10	1·64	0·62	0·65, 0·61
L53	D/8262	0·10	0·03	0·05	—	0·05	10·55	0·18	0·19, 0·18
D.T.D.424A	2130/2	5·00	3·00	0·16	0·23	0·50	0·11	0·69	0·70, 0·70
D.T.D.687	82732	0·27	1·20	5·80	—	0·58	2·70	0·34	0·32, 0·31
BA42	81101/5	12·65	0·87	0·03	2·40	0·007	0·90	0·34	0·35, 0·34
50% Cu	11597	0·14	48·6	—	—	0·10	—	0·23	0·23, 0·23
50% Cu	11608	0·14	50·2	—	—	0·05	—	0·22	0·24, 0·23
20% Ni	1321/1	0·10	0·01	—	21·15	0·01	—	0·47	0·46, 0·47
20% Ni	1325/21	0·11	0·01	—	23·45	0·01	—	0·31	0·32, 0·32

Note 1. Certain unmodified silicon alloys may require a longer period of heating for complete oxidation of silicon.

Note 2. For pure metal containing < 0·1% iron, pipette 50 ml. For alloys containing > 1·2% iron, pipette 10 ml.

Note 3. For 50% copper hardener and 20% nickel hardener, add 5 ml. extra *o*-phenanthroline solution (0·15%).

Conclusions

(1) The absorptiometric *o*-phenanthroline method is applicable to all types of aluminium alloys, hardeners and pure metal without interference from normal alloying elements.

(2) The orange-red *o*-phenanthroline complex, developed in a reduced solution buffered at *p*H 3–4, is very stable, and is unaffected by exposure to light and normal changes in temperature.

(3) A special feature of the method is in the use of a small sample weight in the final solution, which permits the determination to be carried out on all types of alloys without interference from large percentages of other constituents.

(4) Copper, nickel and zinc consume reagent without affecting the iron colour, 5 ml. of a 0·15% *o*-phenanthroline solution are sufficient for all present alloys. Extra reagent is added when analysing copper and nickel hardeners.

(5) The use of a mixed reagent which combines hydroxylamine, buffer and *o*-phenanthroline into a single solution, represents a great saving in time when the method is used under routine conditions. The mixed reagent is very stable.

Acknowledgment

The authors wish to thank The British Aluminium Co., Ltd., for permission to publish this work.

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Institute of Physics Annual Report

At the Annual General Meeting of The Institute of Physics held on 17th May, 1955, Sir John Cockcroft (Director of the Atomic Energy Research Establishment, Harwell) was re-elected President. Dr. W. H. Taylor was elected a Vice-President, and Dr. S. Whitehead and Dr. B. P. Dudding were re-elected Honorary Treasurer and Honorary Secretary, respectively. The three new Ordinary Members of the Board elected were Dr. M. R. Hopkins, Dr. J. M. A. Lenihan and Dr. J. Taylor.

Increased Membership

The Report for 1954, which was adopted at the meeting, shows that the total membership in the several grades continues to increase steadily, and reached 4,749 at the end of the year. The newly established Graduate examination was held in London, Birmingham and Paisley, and of the 54 candidates who sat only 19 satisfied the examiners in those papers they were required to take. The number of candidates taking the final examinations for National Certificates in Applied Physics was 206 at the Ordinary level and 75 for the Higher Certificate; these figures compare with 151 and 55 respectively in 1953.

Arising from reports to the Membership Committee indicating that there were several vacancies for undergraduates in departments of physics in some universities and large technical colleges, the Board decided that an enquiry should be made covering the physics departments of all universities in Great Britain, and all the colleges recognised by the Institute.

The work involved in the production and distribution of the Institute's publications has continued to increase and now forms about half of the total work of the Institute, the principal part being its monthly journals, the *Journal of Scientific Instruments* and the *British Journal of Applied Physics*, which was established in 1950 and "is rapidly obtaining for itself a place among the leading scientific journals".

A third selection of Laboratory and Workshop Notes from the *Journal of Scientific Instruments* was published by Messrs. Edward Arnold (Publishers) Ltd., for the Institute. As with the first two volumes in this series the royalties are credited to the Institute's Benevolent Fund.

The Report states that the day-to-day enquiries on professional matters have included such items as advice on consulting fees and salaries, deferment from military service, appropriate education and training in physics and its special branches and its ancillary subjects, and on sources of technical information.

Employment of Physics Graduates

For the second year an enquiry was addressed to all new graduates in physics of universities in the United Kingdom. They were again asked to provide information about their present occupations and, if appropriate, the source of any maintenance grant. There was a good response. It is proposed to carry out such a survey in each of the next few years, and to follow up the returns by making a subsequent enquiry of those at present engaged on research leading to higher degrees. In this way it should be possible to obtain information that will indicate clearly the way in which the services of physics graduates are being used.

In addition to the several specialist conferences held by the Institute's Branches and subject Groups, a Conference on "The Physics of Particle Size Analysis" was held in Nottingham in April, the proceedings of which were published as a supplement to the *British Journal of Applied Physics*.

The Report shows that the Institute's sixteen local Branches and specialist subject Groups again held many meetings and visited various laboratories and works, and in some instances carried out other functions in connection with their members' special interests.

Brief reports from the Institute's representatives on many outside Committees and Councils conclude the Report of another active year.

Exhibits of Metallurgical Interest at the Physical Society Exhibition

The exhibits at the Physical Society's annual exhibition of scientific instruments usually include a number of interest to workers in the metallurgical field. This year was no exception and in this issue we begin a short series of reviews in which such items will be described.

A New Liquid Air Machine

THE Philips Research Laboratories have concluded a series of developments leading to the manufacture of an entirely new gas refrigerating machine that can be used to produce liquid air.

It is claimed that, with the PW 7000, temperatures of —200° C. can be obtained quickly and simply. The plant has distinct advantages over more orthodox compression refrigerators which, ordinarily, are unable to produce temperatures lower than between —60 and —80° C. The principle of this machine may be compared with that of a heat engine. In a heat engine, energy in the form of heat is transformed into mechanical energy, but if no heat is applied and the machine is driven from an external source of power such as an electric motor, it can be made to function as a refrigerating machine.

The new liquid air machine is comparatively small and is considerably simpler in construction than the "cascade" type of machine usually employed to produce temperatures below —80° C. It also compares favourably in efficiency and simplicity with conventional compression types of refrigerating machines which cannot produce such low temperatures. Because refrigeration takes place without compression, and since there are no expansion valves, the liquid air is pure and free of oil contamination, dust and dirt.

A feature of the new installation is the short starting time required to reach the low working temperature; liquid air is produced within 15 minutes of switching on. The plant will produce 5 litres of liquid air per hour at an ambient temperature of 20° C. and will run continuously for 16 hours in air at a relative humidity of 50%. After this working period, defrosting of the air intake head is necessary, where moisture and carbon dioxide have been deposited as ice and "snow" respectively. De-frosting takes up to one hour, including starting time for the next working cycle. Refrigerating capacity can be varied, both by changing the speed of rotation and by varying the gas pressure within the working space of the machine.

Courtesy of Philips Electrical, Ltd.

PW 7000 liquid air installation.

The installation comprises the liquefier, with built-in air drier, carbon dioxide remover and de-froster on a common bedplate with the 10 h.p. squirrel cage motor. The drive is taken through a flexible uni-directional clutch. The control panel contains indicating gauges, hour meter and control gear. Safety devices close down the plant in the event of failure in the cooling system, pressure system or lubricating system.

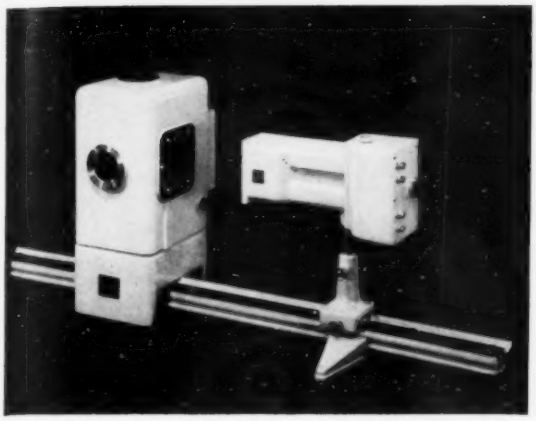
The machine is finding a ready application for local preparation of liquid air in the laboratories of universities, hospitals, research, industrial and commercial establishments. The manufacturers expect, soon, to be able to offer the machine for deep refrigeration of cooling boxes, as well as for liquefication of other gases such as nitrogen, argon, oxygen or methane. In this way liquid baths with a well-defined boiling point can be made readily available.

Hilger Metal Ratio Analyser

The high speed and accuracy obtainable in the analysis of complex metal alloys by large direct reading spectrometers has suggested that there is also a field of use for relatively simple direct reading instruments for quantitative spectrochemical analysis, each of them specifically designed for a single analytical purpose. This might be, for instance, the determination of the zinc content in brasses where the range of concentrations could vary between wide limits, but the actual metallic constituents would remain the same. For such a purpose the high resolution of a spectrograph is not necessary, and quite adequate separation of the appropriate spectral lines can be achieved with a much simpler instrument.

As a result of numerous experiments, it was found that for certain applications such an apparatus could be based on the use of narrow band interference filters associated with photomultiplier cells, and a successful instrument has been devised, capable of use by anybody without any knowledge of spectroscopy.

The analyser, for which a patent is pending, is illustrated here with the spark stand, the stand being designed to take pencil electrodes or a Petrey table. An eyepiece at one end of the analyser allows the alignment of the electrodes to be checked, but with the routine spark stand recommended for use with the



Courtesy of Hilger & Watts, Ltd.
Hilger metal ratio analyser with routine spark stand.

instrument, correct positioning is maintained once the preliminary adjustments have been made.

Light from the spark stand passes through two channels, one above the other, and falls on two photomultipliers housed in the analyser. In one channel is a combination of filters transmitting three strong characteristic spectrum lines of copper, and in the other there is a special interference filter and auxiliary filters passing a characteristic spectrum line of zinc. Each path ends in a separate photomultiplier cell which is connected to an electronic measuring unit where the relative outputs from the two cells are measured.

The electronic unit consists of a stabilised power supply, integrating condensers, and a measuring circuit together with pre-spark and exposure timers. Separate sensitivity controls are provided for each channel. In the normal method of use the exposure is terminated when the charge on one of the integrating condensers reaches a certain level, so that a single measurement of the charge on the other condenser gives a direct reading of the ratio of the intensities of the two channels. Alternatively, an exposure may be made for a fixed time. For adjustment purposes the emission in each channel can be measured continuously without integration. All readings are made on an open scale meter, and when translated through a calibration curve they give the relative quantities of the two constituents in the alloy.

The application of the instrument is, of course, limited to some extent by the complexity of the spectra of the substances to be determined, since the filters are less selective than a monochromator would be. Its great advantage is the speed with which results can be obtained. Given a sample in a suitable form, a simple analysis such as that already described can be carried out in less than a minute. A second advantage is the fact that it can be used in routine analysis by anyone capable of reading a meter and translating a result from a given calibration curve. No knowledge of spectroscopy whatsoever is required.

The instrument is not necessarily restricted to the analysis of binary alloys. It has also been used for the determination of magnesium in a restricted range of aluminium alloys. On assembly each instrument is fitted with a combination of filters suitable for the work to be undertaken. Each problem is considered separately and the individual instruments are built to suit the customer's special requirements. The Development Department of Hilger & Watts, Ltd., will be glad to investigate the possibility of using the instrument for any one component analysis in which intending purchasers may be interested.

Brasses containing 25% to 40% zinc have been analysed, the coefficient of variation of individual results being about 0·5% of the zinc content. This degree of accuracy can be obtained with most samples, but there are cases where inhomogeneity in the brass itself limits the overall accuracy obtainable.

The analyser is a compact unit designed for mounting on a standard accessory bar, which also carries the spark discharge stand. It is provided with a telescope system for aligning it with the light source. The measuring unit includes a power supply for the photomultipliers, timing devices for the pre-spark and exposure times, high quality condensers and the measuring meter.

Electron Microscope

The Metropolitan-Vickers type EM3A electron microscope shown this year incorporates a considerable number of modifications and improvements as compared with the type EM3 shown in previous exhibitions. These modifications are indicated below.

Facilities for reflection microscopy are built into this model, the transverse and tilting mechanism for the electron gun being so designed that a tilt of 10° is obtainable in one direction for surface reflection working. This tilting action is continuous from the upright position.

A new type of electron gun is fitted and a number of modifications have been adopted which improve the stability of the electron beam.

The gun anode is integral with the top face of the condenser lens, as on the EM3, but in addition an anode aperture plate is fitted which can be moved laterally by means of two screwed pushrods operated through the vacuum wall. This adjustment allows the diverging

Courtesy of Metropolitan-Vickers Electrical Co., Ltd.
The type EM3A electron microscope.

electrostatic lens at the anode aperture to be used to correct misalignment of the electron beam due to random lateral displacement of the filament tip. The gun can, therefore, be kept operating at maximum brightness, which is particularly helpful for successful reflection working.

An auxiliary window which assists in setting up specimens for reflection microscopy has been added to the specimen chamber, and a pre-specimen aperture is also provided. A door-mounted reflection stage has been developed which can be substituted for the normal specimen stage door. This reflection stage is designed to handle specimens up to $\frac{1}{2}$ in. diameter and $\frac{5}{16}$ in. thickness. The specimen can be traversed in two directions in a plane normal to the main axis by means of external controls, and can be tilted through an angle of approximately 10° in order to obtain the desired angle of incidence for the reflected beam. It can also be rotated on its own axis through 360°.

The objective lens fitted to this microscope is of new design and incorporates water-cooled windings. An adjustable objective aperture assembly is built into this lens, and takes the form of a rod with the aperture disc in a holder on the end, passing radially into the space between the pole pieces through the non-magnetic spacer. The position of this rod is controlled from outside by two micrometer screws. It can be withdrawn from the beam when no aperture is required, and the whole assembly can be removed from the lens for changing the apertures without dismantling the microscope column. Water cooling is only necessary when the lens is being operated at 4,000 to 6,000 ampere-turns to obtain the highest possible resolution. An astigmatism corrector is fitted to the objective lens.

Improved Direct Reading pH Meter

A NEW direct reading *p*H meter, Model 23A, exhibited by Electronic Instruments, Ltd., is a development of the Model 23, which was originally introduced in 1947 and which, it is claimed, was the first direct reading *p*H meter to become commercially established in this country. The direct reading *p*H meter has the important advantage that it can be used by unskilled personnel as, once the instrument is standardised, it is only necessary to dip the electrode system into the solution being measured and to note the *p*H reading on the scale. In the same way, changes in *p*H may be continuously recorded without manual intervention by the operator.

The Model 23A retains all the well known features of the earlier model, but there are two important improvements. Automatic temperature compensation has now been perfected, so as to make the *p*H readings independent of changes in temperature of the solution being measured; this makes it no longer necessary to standardise the electrodes at the working temperature, and to apply corrections to the *p*H readings if the temperature limits are exceeded. The second improvement is the provision of a higher output current (100 microamps per *p*H unit) for operating recording or control instruments, and also the new E.I.L. electro-pneumatic converter for direct connection to air-operated instruments.

The Model 23A will maintain a zero stability of 0·02 *p*H almost indefinitely, despite any normal variations in mains voltage or frequency. In order to take full advantage of the exceptional stability and accuracy of the instrument, a six-inch hand-calibrated mirror-scale meter is provided, which enables readings to be made to 0·05 *p*H. The full range of E.I.L. *p*H electrodes may be used with the Model 23A, including special electrode systems for micro-analysis and for continuous sampling under anaerobic conditions.

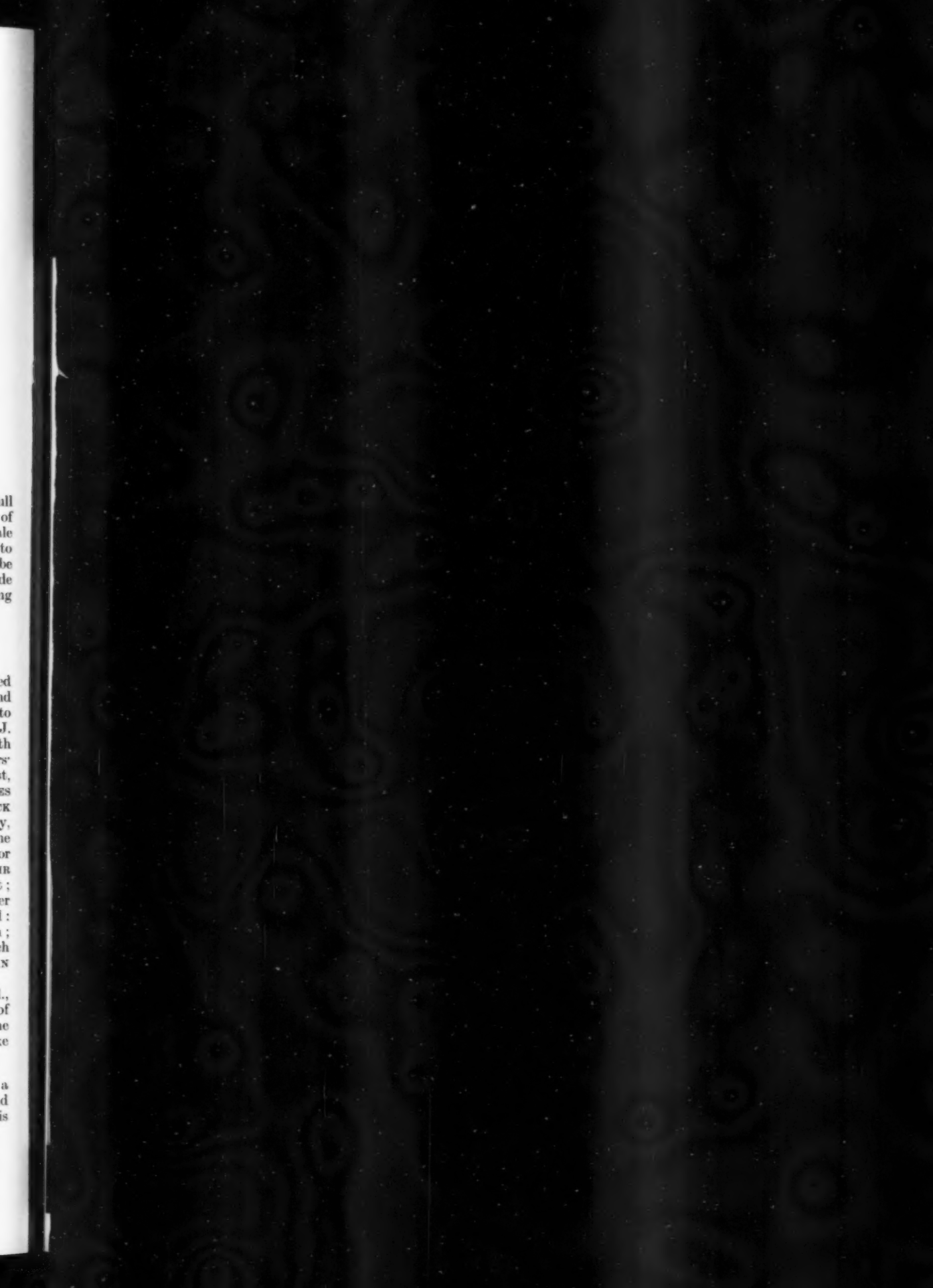
Courtesy of Electronic Instruments, Ltd.

Improved direct reading pH meter.

Kelvin Hughes Retirement Party

ON Monday evening May 9th, more than 120 distinguished people associated with aviation, shipping, industrial and Government circles attended a private cocktail party to mark the retirement of MR. F. A. KING and MR. A. J. HUGHES from the Board of Kelvin & Hughes, Ltd. Both have been associated with the company for nearly 60 years.

There were many well-known names on the guest list, including, from the field of aviation: CAPT. O. P. JONES and CAPT. M. J. R. ALDERSON, B.O.A.C.; SIR FREDERICK HANDLEY PAGE; and DR. A. M. BALLANTYNE, Secretary, Royal Aeronautical Society. Guests from the marine world included: CAPT. WYNNE-EDWARDS, Director Admiralty Compass Observatory; Admiral SIR ARCHIBALD DAY, Admiralty Hydrographic Department; and MR. J. CROFT BAKER, President British Trawler Federation, Ltd. Other names of interest included: DR. A. J. PHILPOT, Scientific Instrument Association; MR. E. T. JONES, Principal Director Scientific Research M.O.S.; LT. COL. LORD DORCHESTER; and ALDERMAN CHARLES PAICE, Mayor of Basingstoke.

The Managing Director of Kelvin & Hughes Ltd., MR. G. B. G. POTTER was present, while directors of associated companies in the Kelvin Hughes group came from the company's factories at Barkingside, Basingstoke and Hillington (Glasgow).

BAIRD & TATLOCK (London), Ltd., have received a contract to furnish the laboratories of the Luton and South Bedfordshire College of Further Education. This contract is valued at £26,900.